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(54)【発明の名称】　面位置検出装置及びそれを用いた半導体素子の製造方法

(57)【特許請求の範囲】

【請求項１】　光照射手段からの少なくとも５本の光束を被検面に斜め方向から該被検面の被検領域中の複数点に各々入射させ、該被検面からの少なくとも５本の反射光束を検出手段で検出し、該検出手段からの出力信号を利用して該被検面の面位置情報を検出する際、該光照射手段からの該少なくとも５本の光束は、該被検面を該被検面に垂直な方向から観察したときに該少なくとも５本の光束が互いに独立して観察されるように光路配置されて入射され、前記複数点それぞれからの反射光を個別の光学系を介して前記検出手段で検出していることを特徴とする面位置検出装置。

【請求項２】　前記光照射手段からの５本の光束が、互いにほぼ同じ入射角ϕ（前記垂直方向に対する角度）で前記被検面に入射せしめられ、該入射角ϕが、$\phi \geqq 70$°を満たすことを特徴とする請求項１の面位置検出装置。

【請求項３】　前記光照射手段は共通の光学系を介して前記少なくとも５本の光束を前記複数点にそれぞれ導き、該複数点からの反射光束は共通の光学系を介した後、前記個別の光学系を介して前記検出手段で検出されることを特徴とする請求項１又は２の面位置検出装置。

【請求項４】　レチクルの回路パターンを投影光学系によりウエハ面上所定方向に配列された複数のショット領域に投影露光する過程を介して半導体素子を製造する際、光照射手段からの少なくとも５本の光束をウエハ面上のショット領域中の複数点に斜め方向から、該ショット領域の中心及び夫々が所定の四角形の頂点に位置する４つの点に、該ショット領域を該ショット領域に垂直な方向から観察したときに該少なくとも５本の光束が互い

に独立して観察されるように光路配置して入射させ、該ショット領域からの少なくとも５本の反射光束を個別の光学系を介して検出手段で検出し、該検出手段からの出力信号を利用して該ショット領域の面位置情報を検出し、該面位置情報に基づいて該ショット領域を該投影光学系の像面に位置付けた後に該レチクルの回路パターンを該投影光学系により該ショット領域に投影露光したことを特徴とする半導体素子の製造方法。

【請求項５】　前記光照射手段からの５本の光束が、互いにほぼ同じ入射角φ（前記垂直方向に対する角度）で前記被検面に入射せしめられ、該入射角φが、φ≧７０°を満たすことを特徴とする請求項４の半導体素子の製造方法。

【請求項６】　前記光照射手段は共通の光学系を介して前記少なくとも５本の光束を前記複数点にそれぞれ導き、該複数点からの反射光束は共通の光学系を介した後、前記個別の光学系を介して前記検出手段で検出されることを特徴とする請求項４又は５の半導体素子の製造方法。

【請求項７】　前記少なくとも５本の光束は前記複数の被検領域の配列された所定の方向に対して０°でない所定角度θだけ被検面内で回転させた方向より入射されることを特徴とする請求項１乃至３のいずれかの面位置検出装置。

【請求項８】　前記少なくとも５本の光束は前記所定の方向に対して０°でない所定角度θだけ被検面内で回転させた方向より入射されることを特徴とする請求項４乃至６のいずれかの半導体素子の製造方法。

【発明の詳細な説明】

【０００１】

【産業上の利用分野】本発明は半導体素子製造用の投影露光装置において、レチクル面上に形成されている電子回路パターンを投影光学系によりウエハ面上に縮小投影する際に、該ウエハ面上の複数点の面位置情報（高さ情報）を検出し、該ウエハの露光領域を投影光学系の最良結像面に容易に位置させることができ、良好なる投影像が得られる面位置検出装置及びそれを用いた半導体素子の製造方法に関するものである。

【０００２】

【従来の技術】近年、半導体素子製造用の投影露光装置には電子回路パターンの微細化、例えばサブミクロンからハーフミクロン程度の微細化及び高集積化が要求されている。そしれこれに伴ない投影光学系に対しては従来以上に高い解像力を有したものが要求されている。この為例えば投影光学系においては高Ｎ．Ａ化そして露光波長に対しては短波長化が図られている。

【０００３】一般に投影光学系の高解像力化を図ろうとＮ．Ａを高くするとパターン投影の許容焦点深度が浅くなってくる。この為多くの投影露光装置では投影光学系の焦点面位置を検出する面位置検出装置が用いられている。この面位置検出装置に対しては単にパターン転写を行なうウエハ面上の露光領域の高さ位置（面位置）情報を検出、調整するのみではなく、パターン転写を行なうウエハ面上の露光領域の傾き等も同時に検出し、調整できることが要望されている。

【０００４】従来より焦点面の面位置検出装置としてはウエハ面上の露光領域の周辺部に複数個のエアセンサーを設け、該エアセンサーより得られた露光領域周辺部の高さ情報より露光領域の傾き及び高さ位置等を算出し調整する方法が知られている。

【０００５】この他、特公平２－１０３６１号公報では露光領域の中心部の高さ情報を斜入射の高さ位置検出光学系により検出、調整し、これとは別に設けた斜入射の傾き検出光学系（コリメータ）により露光領域内の傾きを検出、調整する方法が提案されている。

【０００６】

【発明が解決しようとする課題】一般にパターン転写を行なうウエハ面上の露光領域に凹凸や滑らかな傾きがあると、該露光領域を投影光学系の許容焦点深度内に位置させることが大変難しい。

【０００７】例えば図１３に示すようにウエハ面上の露光領域９０が滑らかな凸状（凹状であっても以下同様である。）となっていたとする。このとき前者の露光領域の複数の周辺部にエアセンサーを配置して計測する方法では、図１４に示すように露光領域９０の複数の周辺部の測定点９１ａにおける位置を投影光学系の最良結像面９２に合致させることができる。しかしながら露光領域９０の中央部９１ｂは許容焦点深度内９３から外れてしまうという問題点があった。

【０００８】又、後者の斜入射による高さ位置検出光学系と傾き検出光学系を用いる方法は図１５に示すように露光領域９０の中央部の測定点９４の位置を投影光学系の最良結像面９２に合致させると共に露光領域全体の平均的な傾き９５を最良結像面９２に平行とすることができる。

【０００９】しかしながらこの方法は露光領域９０の周辺部は許容焦点深度内９３に位置させることができないという問題点があった。このときの問題点は、例えば図１６に示すように露光領域９０内に中央部と周辺部に複数の測定点９６をとれば露光領域９０全体を許容焦点深度内９３に位置させることができる。

【００１０】しかしながらこの方法は半導体素子製造用の投影露光装置においては投影光学系の下方、空間には即ちウエハステージ周辺部の空間にはウエハステージ制御用のレーザ干渉計やウエハ位置合わせ用の顕微鏡等の部材を配置している為、複数の面位置検出装置を設けることは大変難しいという問題点があった。

【００１１】本発明はウエハ面上の露光領域内の複数点の高さ情報（面位置情報）を適切に設定した面位置検出装置により検出し、これによりウエハ面が凹凸形状をし

ていても、又傾いていても該ウエハ面上の露光領域全体を投影光学系の許容焦点深度内に容易に位置させることができる。これにより高密度の半導体素子を製造することができる面位置検出装置及びそれを用いた半導体素子の製造方法の提供を目的とする。

【0012】

【課題を解決するための手段】本発明の面位置検出装置は、

（1－1）光照射手段からの少なくとも5本の光束を被検面に斜め方向から該被検面の被検領域中の複数点に各々入射させ、該被検面からの少なくとも5本の反射光束を検出手段で検出し、該検出手段からの出力信号を利用して該被検面の面位置情報を検出する際、該光照射手段からの該少なくとも5本の光束は、該被検面を該被検面に垂直な方向から観察したときに該少なくとも5本の光束が互いに独立して観察されるように光路配置されて入射され、前記複数点それぞれからの反射光を個別の光学系を介して前記検出手段で検出していることを特徴としている。特に、

（1－1－1）前記光照射手段からの5本の光束が、互いにほぼ同じ入射角φ（前記垂直方向に対する角度）で前記被検面に入射せしめられ、該入射角φが、φ≧70°を満たすこと。

（1－1－2）前記光照射手段は共通の光学系を介して前記少なくとも5本の光束を前記複数点にそれぞれ導き、該複数点からの反射光束は共通の光学系を介した後、前記個別の光学系を介して前記検出手段で検出されること。

（1－1－3）前記少なくとも5本の光束は前記複数の被検領域の配列された所定の方向に対して0°でない所定角度θだけ被検面内で回転させた方向より入射されること。等を特徴としている。

【0013】又、本発明の半導体素子の製造方法は、

（2－1）レチクルの回路パターンを投影光学系によりウエハ面上所定方向に配列された複数のショット領域に投影露光する過程を介して半導体素子を製造する際、光照射手段からの少なくとも5本の光束をウエハ面上のショット領域中の複数点に斜め方向から、該ショット領域の中心及び夫々が所定の四角形の頂点に位置する4つの点に、該ショット領域を該ショット領域に垂直な方向から観察したときに該少なくとも5本の光束が互いに独立して観察されるように光路配置して入射させ、該ショット領域からの少なくとも5本の反射光束を個別の光学系を介して検出手段で検出し、該検出手段からの出力信号を利用して該ショット領域の面位置情報を検出し、該面位置情報に基づいて該ショット領域を該投影光学系の像面に位置付けた後に該レチクルの回路パターンを該投影光学系により該ショット領域に投影露光したことを特徴としている。特に、

（2－1－1）前記光照射手段からの5本の光束が、互いにほぼ同じ入射角φ（前記垂直方向に対する角度）で前記被検面に入射せしめられ、該入射角φが、φ≧70°を満たすこと。

（2－1－2）前記光照射手段は共通の光学系を介して前記少なくとも5本の光束を前記複数点にそれぞれ導き、該複数点からの反射光束は共通の光学系を介した後、前記個別の光学系を介して前記検出手段で検出されること。

（2－1－3）前記少なくとも5本の光束は前記所定の方向に対して0°でない所定角度θだけ被検面内で回転させた方向より入射されること。等を特徴としている。

【0014】

【実施例】図1は本発明の実施例1の要部概略図、図2は図1の一部分の拡大説明図である。

【0015】図1において1は縮小型の投影光学系（投影レンズ系）、Axは投影光学系1の光軸である。1aはレチクルであり、その面上には回路パターンが形成されており、レチクルステージ1b上に載置している。1cは照明系であり、レチクル1a面上を均一照明している。投影光学系1はレチクル1a面上の回路パターンをウエハ2面上に縮小投影している。ウエハ2はウエハステージ3面上に吸着固定している。ウエハステージ3は投影光学系1の光軸Ax方向（z方向）と光軸Axを直交する面内（x－y平面内）の2方向（x，y方向）に移動可能で、かつ光軸Axと直交する平面（x－y平面）に対して傾き調整できるようになっている。これによりウエハステージ3面上に載置したウエハ2の面位置を任意に調整できるようにしている。4はステージ制御装置であり、後述するフォーカス制御装置18からの信号に基づいてウエハステージ3を駆動制御している。

【0016】SAは光照射手段、SBは投影手段、SCは光電変換手段であり、これらはウエハ2面の面位置情報を検出する面位置検出装置の一部分を構成している。尚、投影手段SBと光電変換手段SCとで検出手段SBCを構成している。

【0017】本実施例では面位置検出装置を用いてレチクル1a面上の回路パターンを投影光学系1でウエハ2面上に投影する際に、投影光学系1の許容焦点深度内にウエハ2面上の露光領域が位置するようにウエハステージ3を駆動制御している。そしてウエハステージ3をX－Y平面上で逐次移動させ、これにより矩形状のパターン領域（ショット）39（20mm×20mm程度）をウエハ2面上に順次形成している。

【0018】次に本実施例の面位置検出装置の各要素について説明する。まずウエハ2面上に複数の光束を入射させる光照射手段SAについて説明する。

【0019】5は光源であり、白色ランプ又は相異なる複数の波長の光を照射するように構成した照明ユニットより成っている。6はコリメーターレンズであり、光源5からの光束を断面の強度分布が略均一の平行光束とし

て射出している。７はプリズム形状のスリット部材であり、複数の開口（５つのピンホール）７１～７５を有している。８はレンズ系であり、両テレセントリック系より成りスリット部材７の複数のピンホール７１～７５を通過した独立の５つの光束７１ａ～７５ａをミラー９を介してウエハ２面上の５つの測定点１９～２３に導光している。このとき投影像の大きさが略等しいピンホール像となるようにしている。又、このレンズ系８は内部に各光束７１ａ～７５ａのＮ．Ａをそろえる為の開口絞り４０を有している。本実施例では以上の各要素５，６，７，８，９より光照射手段ＳＡを構成している。

【００２０】本実施例において光照射手段ＳＡからの各光束のウエハ２面上への入射角φ（ウエハ面に立てた垂線と成す角）はφ＝７０°以上である。ウエハ２面上には図２に示すように複数個のパターン領域（露光領域ショット）３９が配列している。レンズ系８を通過した５つの光束７１ａ～７５ａはパターン領域３９の互いに独立した各測定点１９～２３に入射している。

【００２１】そしてウエハ２面上に入射する５つの光束７１ａ～７５ａがウエハ２の垂直方向（光軸Ａｘ方向）から観察したとき図２に示すように互いに独立して観察されるようにウエハ２面上にＸ方向（ショット配列方向）からＸＹ平面内でθ°回転させた方向より入射させている。尚、スリット部材７の５個のピンホール７１～７５はウエハ２面とシャインプルーフの条件を満足するようにウエハ２と共役な同一平面上に設けている。又ピンホール部材７のピンホール７１～７５の大きさと形状、そしてレンズ系８からの距離等はウエハ２面上で互いに略同一の大きさのピンホール像を形成するように設定している。

【００２２】本実施例では以上の各要素５，６，７，８，９から成る光照射手段ＳＡにより、ウエハ２面上に複数の光束（ピンホール）を入射させている。尚、本実施例においてウエハ２面上の測定点は５点に限らずいくつあっても良い。

【００２３】次にウエハ２面からの複数の反射光束をＣＣＤより成る位置検出素子としての光電変換手段ＳＣの検出面１７に導光し、結像させる投影手段ＳＢについて説明する。

【００２４】１１は受光レンズであり、両テレセントリック系より成り、ウエハ２面からの５つの反射光束をミラー１０を介して反射している。そして受光レンズ１１は各測定点１９～２３に対して各位置２４～２８にピンホール像を形成している。各位置２４～２８のピンホール像からの光束は独立に設けた５つの補正光学系１２～１６に入光している。

【００２５】補正光学系１２～１６は受光レンズ１１が両テレセントリック系であるので、その光軸が互いに平行となっており、各位置２４～２８に形成したピンホール像を光電変換手段ＳＣの検出面１７上に互いに同一の

大きさのスポット光となるよう再結像させている。光電変換手段ＳＣは単一の２次元ＣＣＤより成っている。本実施例では以上の各要素１０，１１，１２～１６より投影手段ＳＢを構成している。

【００２６】尚、補正光学系１２～１６は各々所定の厚さの平行平面板とレンズ系を有しており、受光レンズ１１の光軸に対して共軸あるいは偏心している。このとき平行平面板は各レンズ系の光路長を補正する為に用いている。又レンズ系は各測定点１９～２３の検出面１７上における結像倍率（投影倍率）が略等しくなるように補正する為に設けている。

【００２７】即ち、本実施例の如く複数の光束をウエハ面上に斜入射させる斜入射結像光学系では受光レンズ１１に対して距離の異なる複数の測定点１９～２３が光電変換手段ＳＣの検出面１７上に結像する際、その結像倍率が互いに異なってくる。

【００２８】そこで本実施例では各測定点に対して補正光学系１２～１６を設けて、これらの各測定点１９～２３の検出面１７上における投影倍率が略等しくなるようにしている。（尚、この補正光学系については本出願人の先の特願平２－４４２３６号で詳細に説明している。）そしてこのときウエハ２面の各測定点１９～２３の面位置（高さ方向、光軸Ａｘ方向）によって検出面１７上に入射するピンホール像（スポット光）の位置が変化するようにしている。光電変換手段ＳＣはこのときのピンホール像の位置変化を検出している。これにより本実施例ではウエハ２面上の各測定点１９～２３の面位置情報を同一精度で検出できるようにしている。

【００２９】又、投影手段ＳＢを介してウエハ２面上の各測定点１９～２３と光電変換手段ＳＣの検出面１７とが互いに共役となるようにして（各測定点１９～２３に対して倒れ補正を行なって）いる。これにより各測定点１９～２３の局所的な傾きによって検出面１７上でのピンホール像の位置が変化せず、ウエハ２の表面の光軸Ａｘ方向の各測定点の局所的な高さ位置の変化、即ち測定点１９～２３の高さに応答して検出面１７上でのピンホール像の位置が変化するようにしている。光電変換手段ＳＣは検出面１７面上に入射したピンホール像の入射位置情報を検出している。光電変換手段ＳＣで得られた各測定点１９～２３におけるピンホール像の入射位置情報はフォーカス制御手段１８に入力している。

【００３０】フォーカス制御手段１８は光電変換手段ＳＣからの各測定点１９～２３の高さ情報（面位置情報）を得て、これよりウエハ２の表面の位置情報、即ち光軸Ａｘ方向（ｚ方向）に関する位置やＸ－Ｙ平面に対する傾き等を求めている。

【００３１】そしてウエハ２の表面が投影光学系１によるレチクル１ａの投影面と略一致するようにウエハステージ３の駆動量に関する信号をステージ制御装置４に入力している。ステージ制御装置４はフォーカス制御手段

１８からの入力信号に応じてウエハステージ３を駆動制御し、ウエハ２の位置と姿勢を調整している。

【００３２】次に本実施例においてウエハ２面上の複数の測定点（１９〜２３）に光束を入射させピンホール像を形成する際の各要素の配置上の特徴について説明する。

【００３３】本実施例におけるウエハ２面上の複数の測定点１９〜２３は図２に示すようにウエハ２の矩形状のパターン領域（ショット）３９の４隅及びその４隅の略中心に設定している。そして光照射手段ＳＡにより矩形状のパターン領域３９のＸ方向より角度θ（同図ではθ＝２２．５°）回転させた方向より各ピンホール７１〜７５と出た光束を各測定点７１〜７５に照射している。

【００３４】このとき光照射手段ＳＡの各ピンホール７１〜７５からの光束がウエハ２の垂直方向から観察したとき、互いに独立して観察されるようにウエハ２面上に入射させている。

【００３５】図３は図１のＡ－Ａ´断面内における補正光学系１２〜１６の空間配置を示す説明図である。

【００３６】本実施例では図１の入射角φはφ＝７０°以上となるように斜入射させている。従って補正光学系１２〜１６の中心間の相対距離は光照射手段ＳＡからの光束がウエハ２面上に斜入射していることにより、ウエハ２面上で等間隔の測定点を形成しようとすると図３のａａ´方向はｂｂ´方向に比べてｃｏｓφ倍、即ち０．３４倍以下と狭くなってくる。

【００３７】又、一般に補正光学系１２〜１６の直径は製造上、少なくても４〜５mm程度は必要となるので複数の補正光学系を互いにメカニカルに干渉しないように配置することが難しくなってくる。

【００３８】そこで本実施例では光照射手段ＳＡからの光束に対して矩形状のパターン領域３９を図２に示すようにθ≒２２．５°回転させている。これにより補正光学系１２〜１６の中心が互いにａａ´方向とｂｂ´方向共に同一の座標を持つことなく、空間的に各々独立に配置できるようにしている。尚、このときの角度θは２２．５°に限らず前述の如く５つの光束７１ａ〜７５ａがウエハ２面の垂直方向から見たとき、互いに独立して観察される角度であれば良い。

【００３９】図４は図２に示す角度θをθ＝０°としたときのウエハ２面上に入射する５つの光束の入射状態を示したものである。同図に示すように測定点１９と２２及び測定点２０と２３に入射した光束は互いに重なって観察される。

【００４０】図５は図４に示す如く光束を入射させたときの補正光学系１２〜１６の空間配置の説明図である。同図に示すように測定点１９と２２に対応する補正光学系１２と１５がメカニカルに干渉し、測定点２０と２３に対応する補正光学系１３と１６とがメカニカルに干渉し、この為これらの補正光学系を空間的に配置するのができなくなってくる。

【００４１】図６は同様に角度θ＝４５°としたときのウエハ２面上に入射する５つの光束の入射状態を示したものである。同図に示すように測定点１９，２１，２３に入射した光束が互いに重なって観察される。

【００４２】図７は図６に示す如く光束を入射させたときの補正光学系１２〜１６の空間配置の説明図である。測定点１９，２１，２３に対応する補正光学系１２，１４，１６は互いにメカニカルに干渉するので、これらの補正光学系を空間的に配置するのが出来なくなってくる。

【００４３】これに対して本実施例では前述の如くθ≒２２．５°とし、補正光学系１２〜１６の各々中心間の距離が図３に示すように離れた空間配置となるようにして、補正光学系１２〜１６が空間的に容易に配置することができるようにしている。

【００４４】本実施例においては以上のように各要素を構成することにより、光照射手段ＳＡによりウエハ２面上の５つの測定点１９〜２３に前述の如く大きさの略等しいピンホール像を照射（形成）している。そして各測定点１９〜２３からの５つの反射光を用いて投影手段ＳＢにより光電変換手段ＳＣの検出面１７に大きさの略等しいピンホール像を再結像させている。このときウエハ２面の高さ（光軸Ａｘ方向）によって変化する検出面１７上に入射するピンホール像の入射位置情報を光電変換手段ＳＣにより検出している。そして光電変換手段ＳＣはこのときの検出面１７上におけるピンホール像の入射位置情報をフォーカス制御装置１８に入力している。フォーカス制御装置１８は光電変換手段ＳＣからの信号に基づいてウエハ２の高さを各測定点１９〜２３毎に求め、このとき得られた高さ情報をステージ制御装置４に入力している。

【００４５】ステージ制御装置４はフォーカス制御装置１８からの信号に基づいてウエハステージ３を駆動させ、これよりウエハ２を投影光学系１の最良結像面に位置させている。これによりウエハ２面上にレチクル１ａの回路パターンの投影露光を行ない高密度の半導体素子の製造を行なっている。

【００４６】図８は本発明の実施例２の要部概略図である。図８において図１で示した要素と同一要素には同符番を付している。

【００４７】本実施例では図１の実施例１に比べて受光レンズ１１と補正光学系１２〜１６との間の光路中に補正光学系１２〜１６に対応させて５つのミラー２４〜２８を設けて、受光レンズ１１からの光束をこれらのミラー２４〜２８を介して補正光学系１２〜１６に導光している点が異なっており、この他の構成は実質的に同一である。

【００４８】受光レンズ１１によりウエハ２面上の各測定点１９〜２３上に形成したピンホール像を補正光学系

１２～１６の光軸上に配置したミラー３４～３８の反射点近傍の位置２４～２８に再結像している。再結像の位置２４～２８近傍は各々の光束が集光している為、これにより各々の光束に対して個別のミラー３４～３８を他の光束に影響を与えず配置することを可能としている。

【００４９】このように各光束に対して個別にミラー３４～３８を配置し、これにより図９に示すように５つの補正光学系１２～１６を空間的に配置する際、ａａ´方向の相対距離が図３に示すミラーを配置しない場合に比べてより広くとることができ、これにより補正光学系の空間的な配置を容易にしている。

【００５０】図１０は本発明の実施例３の要部概略図である。図１０において図１で示した要素と同一要素には同符番を付している。

【００５１】本実施例では図１の実施例１の光電変換手段ＳＣを単一の２次元ＣＣＤで構成する代わりにウエハ２面上の各測定点１９～２３に対応させた５つの検出素子（１次元ＣＣＤやＰＳＤ等の素子）４１～４５を用いている点と、光路中にミラーを配置して各検出素子にピンホール像を形成し、このときの各検出素子４１～４５を用いて入射するピンホール像の入射位置情報を検出している点が異なっており、この他の構成は実質的に同じである。

【００５２】ウエハ２面上の測定点２０，２２からの光束は受光レンズ１１によりピンホール像が結像される結像点２６，２７近傍に配置したミラー４８，４９で反射させて補正光学系１３，１５に入射させている。そして補正光学系１３，１５により検出素子４２，４４面上にピンホール像を再結像している。このときのミラー４８，４９は光束が集光している位置近傍に配置しているので、他の光束に影響を与えることなく光を反射させている。又ウエハ２面上の測定点１９，２３からの光束は受光レンズ１１により集光し、位置２４，２８にピンホール像を結像し、その後補正光学系１２，１６により集光しミラー４６，４７で反射し、検出素子４１，４５面上に入射している。そして検出素子４１，４５面上にピンホール像を再結像している。

【００５３】又、ウエハ２面上の測定点２１からの光束は受光レンズ１１により集光され位置２６にピンホール像を結像した後、補正光学系１４により検出素子４３面上にピンホール像を再結像している。

【００５４】本実施例ではウエハ２面上に光照射手段ＳＡから複数の光束を入射させる際、ウエハ２に対して図２に示すようにｘ方向に対して方位角θ＝２２．５°程度として入射させ、各光束の空間配置上の間隔が広くなるようにしている。これにより各々の測定点１９～２３に対応して個別の検出素子４１～４５を空間的に容易に配置することができるようにしている。又、各測定点１９～２３に基づく検出素子４１～４５からの出力信号を並列処理することを可能とし、信号処理の高速化を図っている。

【００５５】尚、本実施例では検出素子としてＰＳＤを用いれば１次元ＣＣＤを用いた場合に比べて信号処理回路が簡素化し、又信号処理を高速化することができるので好ましい。

【００５６】図１１は本発明の実施例４の光照射手段ＳＡ部分のみを示す要部概略図である。同図においてスリット部材７以降の構成については図１の構成と同じである。

【００５７】本実施例では光源５０からの光束を集光レンズ５１を用いてファイバー５６の入射面５６ａに入射させ、ファイバー５６の射出面５６ｂから射出した光束によりスリット部材７の１つのピンホール７５を照明している。スリット部材７の他のピンホール７１～７４の照明についても同様の構成の光源、集光レンズ、そしてファイバーを用いて行なっている。光源５０は白色ランプ又は相異なる複数の波長の光束を照射する照明ユリットより成っている。

【００５８】図１２は図１１のスリット部材７のピンホール７１～７５の配置を示すＣ－Ｃ´断面図である。本実施例ではウエハ面上へに光束を入射させるときのｘ方向に対する角度θを図２に示すようにθ＝２２．５°程度、そして各々のピンホール７１～７５の空間的な間隔を広くしている。これにより各々のピンホール７１～７５に対して個別のファイバー５２～５６による照明を可能とし、例えばウエハ２面上の各々の測定点１９～２３の反射率が異なっていても、個別に光量を調整し、各々の測定点１９～２３からの反射光の光量を等しくし、高精度な面位置情報の検出を可能としている。

【００５９】

【発明の効果】本発明によれば以上のように被検領域を該被検領域に垂直な方向から観察した時に少なくとも５本の光束が互いに独立して観察されるように光路配置して複数点に斜め方向から入射させ、この被検領域からの少なくとも５本の反射光束を個別の光学系を介して検出手段で検出する構成としたことにより、斜め入射角度φが急な構成であっても例えば図５や図７に示されるような反射光束の光路同士の極端な近接状態を避けることができ、よって検出系側に個別の（例えば補正）光学系を配置する場合にこれらの空間配置を容易にすることかできる。従って例えば、ウエハ面上の露光領域内の複数点の高さ情報（面位置情報）を適切に設定した面位置検出装置により検出し、これによりウエハ面が凹凸形状をしていても、又傾いていても該ウエハ面上の露光領域全体を投影光学系の許容焦点深度内に容易に位置させることができ、これにより高密度の半導体素子を製造することができる面位置検出装置及びそれを用いた半導体素子の製造方法を達成することができる。

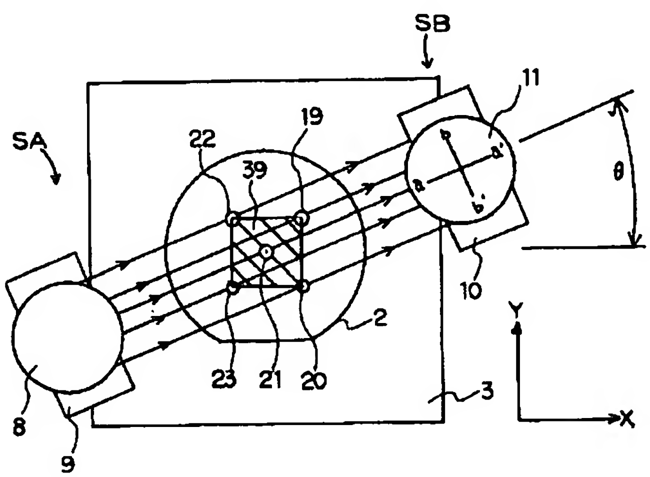
【図面の簡単な説明】

【図１】　本発明の実施例１の要部概略図

【図２】　図１の一部分の拡大説明図
【図３】　図１のａ－ａ´断面図
【図４】　図２の角度θを変えたときの拡大説明図
【図５】　図４で示す場合の補正光学系の配置を示す説明図
【図６】　図２の角度θを変えたときの拡大説明図
【図７】　図６で示す場合の補正光学系の配置を示す説明図
【図８】　本発明の実施例２の要部概略図
【図９】　図８のａ－ａ´断面図
【図１０】　本発明の実施例３の要部概略図
【図１１】　本発明の実施例４の一部分の概略図
【図１２】　図１１のｃ－ｃ´断面図
【図１３】　ウエハ形状の説明図
【図１４】　ウエハ表面と投影レンズの許容焦点深度との位置関係を示す説明図
【図１５】　ウエハ表面と投影レンズの許容焦点深度との位置関係を示す説明図
【図１６】　ウエハ表面と投影レンズの許容焦点深度との位置関係を示す説明図＊

＊【符号の説明】
ＳＡ　光照射手段
ＳＢ　投影手段
ＳＣ　光電変換手段
１　投影レンズ
１ａ　レチクル
２　ウエハ
３　ウエハステージ
４　ステージ制御装置
５　光源
６　コリメーターレンズ
７　スリット部材
８　レンズ系
９，１０　ミラー
１１　受光レンズ
１２～１６　補正光学系
１７　検出面
１８　フォーカス制御装置
７１～７５　ピンホール

【図２】



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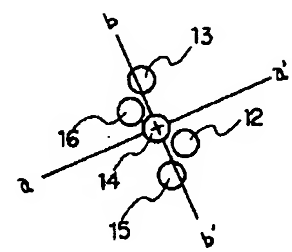

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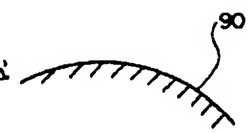

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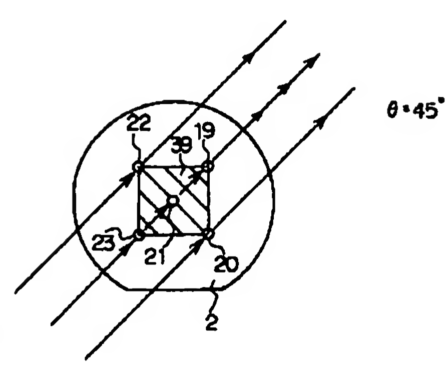

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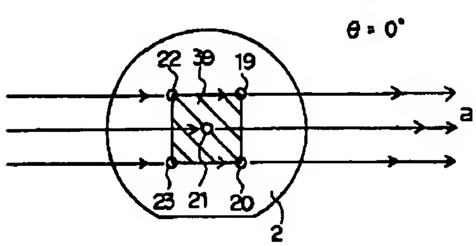

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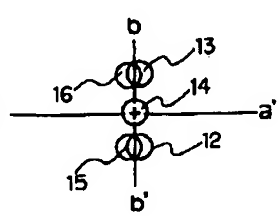

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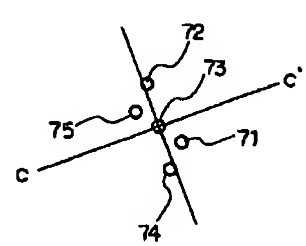

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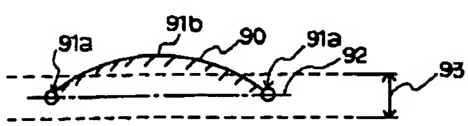

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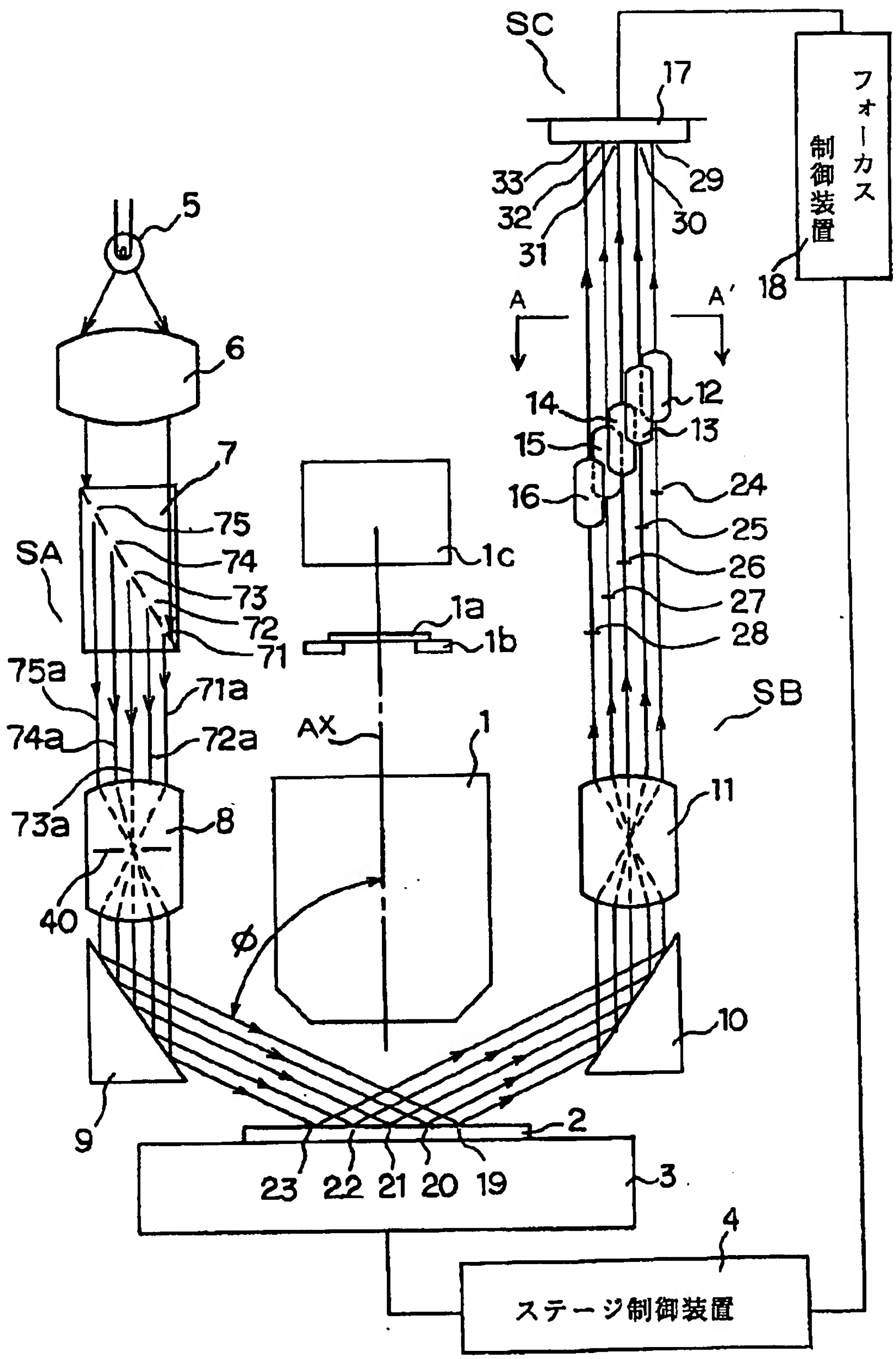
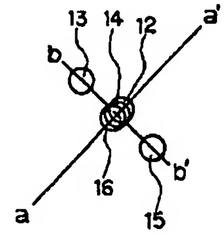
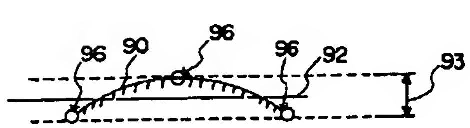

SC
17
33
32
31
29
30
フォーカス制御装置
18
5
6
7
75
74
73
72
71
SA
75a
74a
73a
71a
72a
8
40
9
1c
1a
1b
AX
1
φ
A
A′
14
12
13
15
16
24
25
26
27
28
SB
11
10
2
23 22 21 20 19
3
4
ステージ制御装置

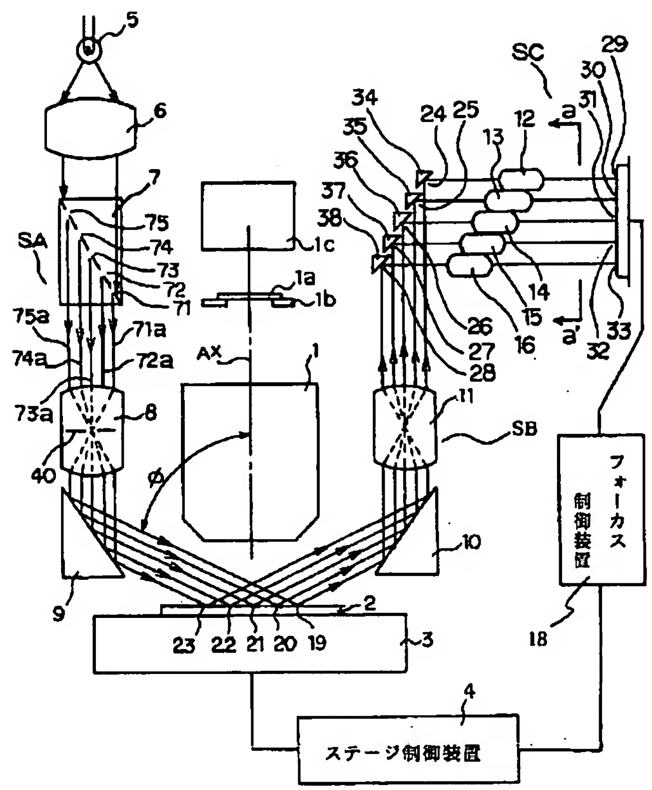
【図７】


13
14
12
a′
b
16
b′
a
15

【図１６】


96
90
96
96
92
93

【図８】



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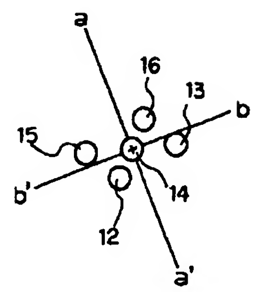

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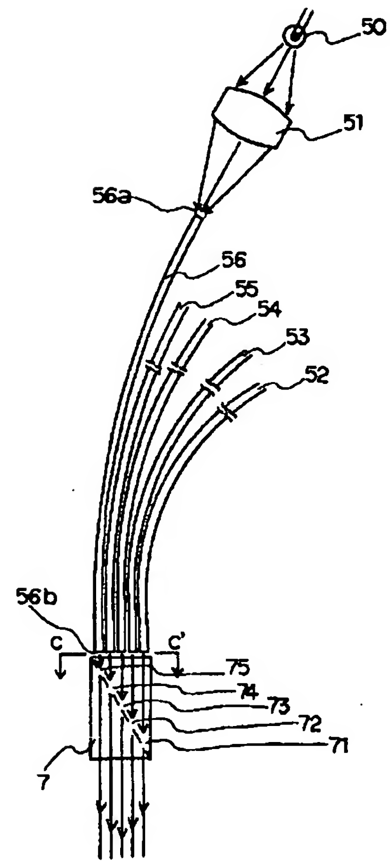

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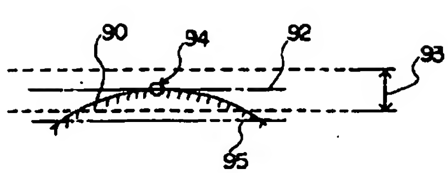

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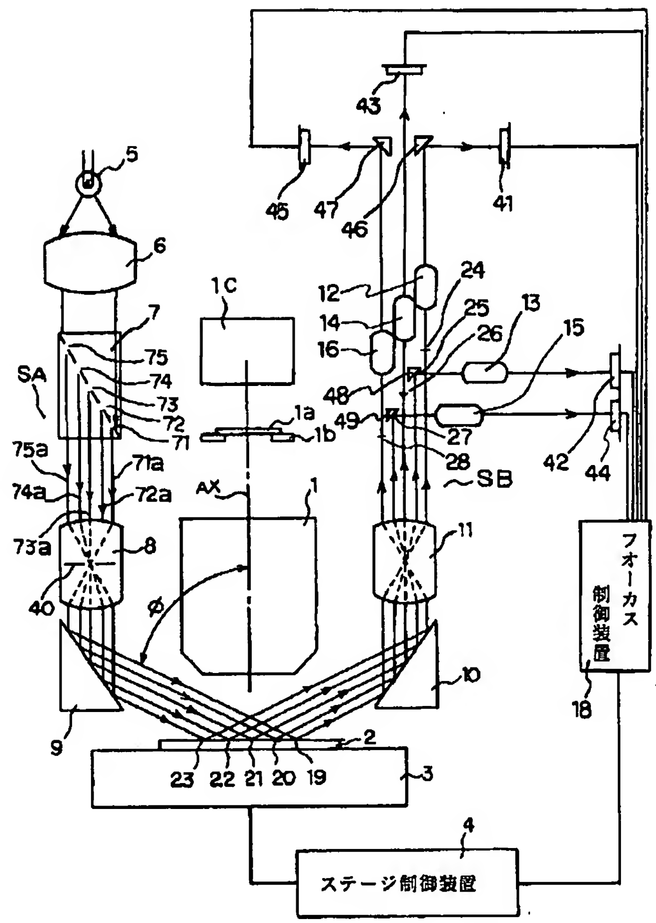

CLAIMS

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(57) [Claim(s)]
[Claim 1]At least five light flux from the Mitsuteru gunner stage is respectively entered in two or more points of a tested area of this specimen plane from an oblique direction at a specimen plane, When a detection means detects at least five reflected light flux from this specimen plane and surface position information of this specimen plane is detected using an output signal from this detection means, This few **** from this optical irradiation means five light flux, A surface position sensing device which optical-path arrangement is carried out and this few **** enters so that five light flux may be observed independently mutually when this specimen plane is observed from a direction vertical to this specimen plane, and is characterized by said thing [that said detection means has detected two or more catoptric light from each point via an individual optical system].
[Claim 2]A surface position sensing device of claim 1, wherein five light flux from said Mitsuteru gunner stage is made to enter into said specimen plane by the mutual almost same incidence angle phi (angle to said perpendicular direction) and this incidence angle phi fills phi>=70 degrees.
[Claim 3]Claim 1 or 2 surface position sensing devices after it leads more than one to a point, respectively and reflected light flux from these two or more points passes said Mitsuteru gunner stage said common optical system for said at least five light flux via a common optical system, wherein it is detected by said detection means via said individual optical system.
[Claim 4]When a semiconductor device is manufactured via a process in which projection exposure of the circuit pattern of reticle is carried out to two or more shot regions arranged by a projection optical system in a wafer surface top determined direction, At least five light flux from the Mitsuteru gunner stage to two or more points of a shot region on a wafer surface from an oblique direction, At four points that a center and each of this shot region are located at a vertex of a predetermined quadrangle. When this shot region is observed from a direction vertical to this shot region, you carry out optical-path arrangement and this few **** makes it enter so that five light flux may be observed independently mutually, A detection means detects at least five reflected light flux from this shot region via an individual optical system, Surface position information of this shot region is detected using an output signal from this detection means, A manufacturing method of a semiconductor device carrying out projection exposure of the circuit pattern of this reticle to this shot region according to this projection optical system after positioning this shot region in the image surface of this projection optical system based on this surface position information.
[Claim 5]A manufacturing method of a semiconductor device of claim 4, wherein five light flux from said Mitsuteru gunner stage is made to enter into said specimen plane by the mutual almost same incidence angle phi (angle to said perpendicular direction) and this incidence angle phi fills phi>=70 degrees.
[Claim 6]Claim 4 after it leads more than one to a point, respectively and reflected light flux from these two or more points passes said Mitsuteru gunner stage said common optical system for said at least five light flux via a common optical system, wherein it is detected by said detection means via said individual optical system, or a manufacturing method of a semiconductor device of 5. [Claim

7]One surface position sensing device of claims 1 thru/or 3, wherein said at least five light flux enters from a direction which rotated only the predetermined angle theta which is not 0 degree within a specimen plane to a predetermined direction in which said two or more tested areas were arranged. [Claim 8]A manufacturing method of one semiconductor device of claims 4 thru/or 6, wherein said at least five light flux enters from a direction which rotated only the predetermined angle theta which is not 0 degree within a specimen plane to said predetermined direction.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application]When this invention carries out reduction projection of the electronic circuit pattern currently formed on the reticle side on a wafer surface according to a projection optical system in the projection aligner for semiconductor device manufacture, The surface position information (height information) of two or more points on this wafer surface can be detected, the exposure region of this wafer can be easily located in the best image formation face of a projection optical system, and it is related with the surface position sensing device with which a good projection image is acquired, and the manufacturing method of a semiconductor device using it.
[0002]
[Description of the Prior Art]In recent years, the minuteness making about a half micron and high integration are demanded of the projection aligner for semiconductor device manufacture from the minuteness making of the electronic circuit pattern, for example, a submicron. censure -- in connection with this, the thing with higher resolution than before is demanded from the projection optical system. For this reason, in the projection optical system, short wavelength formation is attained to the formation of high N.A, and an exposure wavelength.
[0003]Generally, about high-resolving-power-ization of a projection optical system, if a figure wax and N.A are made high, the allowable depth of focus of pattern projection will become shallow. For this reason, with many projection aligners, the surface position sensing device which detects the focal plane position of a projection optical system is used.It is requested that it not only detects and adjusts the height position (surface position) information on the exposure region on the wafer surface which only performs pattern transfer to this surface position sensing device, but it detects simultaneously inclination to the exposure region on the wafer surface which performs pattern transfer, etc., and can adjust them.
[0004]As a surface position sensing device of a focal plane, two or more air sensors are formed in the periphery of the exposure region on a wafer surface from before, and the method of computing and adjusting inclination, a height position, etc. of an exposure region from the height information of the exposure region periphery obtained from this air sensor is known.
[0005]In addition, in JP,2-10361,B, the height information of the central part of an exposure region is detected and adjusted with the height position detecting optical system of oblique incidence, and the method of detecting the inclination in an exposure region and adjusting with the detected inclination optical system (collimator) of oblique incidence established apart from this is proposed.
[0006]
[Problem(s) to be Solved by the Invention]When unevenness and smooth inclination are in the exposure region on the wafer surface which generally performs pattern transfer, it is very difficult to locate this exposure region in the allowable depth of focus of a projection optical system.
[0007]For example, as shown in drawing 13, the exposure region 90 on a wafer surface assumes that

it had become convex [smooth] (it is the same as that of the following even if it is a concave.). The position in the point of measurement 91a of two or more peripheries of the exposure region 90 can be made to agree in the best image formation face 92 of a projection optical system in the method of arranged and measuring an air sensor to two or more peripheries of the former exposure region at this time, as shown in drawing 14. However, there was a problem that the center section 91b of the exposure region 90 will separate from 93 in the allowable depth of focus.

[0008]The method of using the latter height position detecting optical system and detected inclination optical system by oblique incidence makes the position of the point of measurement 94 of the center section of the exposure region 90 agree in the best image formation face 92 of a projection optical system, as shown in drawing 15, and it can make average inclination 95 to the whole exposure region parallel to the best image formation face 92.

[0009]However, this method had the problem that the periphery of the exposure region 90 could not be located in 93 in the allowable depth of focus. The problem at this time can locate the exposure region 90 whole in 93 in the allowable depth of focus, if two or more point of measurement 96 is taken in the exposure region 90 at a center section and a periphery as shown, for example in drawing 16.

[0010]In the projection aligner for semiconductor device manufacture, this method However, the lower part of a projection optical system, Since members, such as a laser interferometer for wafer stage control and a microscope for wafer alignment, were arranged in space, i.e., the space of a wafer stage periphery, there was a problem that it was very difficult to form two or more surface position sensing devices in it.

[0011]Whether the surface position sensing device set up appropriately detects the height information (surface position information) of two or more points in the exposure region on a wafer surface, and the wafer surface is carrying out uneven shape by this or this invention leans, it can locate easily the whole exposure region on this wafer surface in the allowable depth of focus of a projection optical system. It aims at offer of the manufacturing method of a semiconductor device using the surface position sensing device and it which can manufacture a high-density semiconductor device by this.

[0012]

[Means for Solving the Problem]A surface position sensing device of this invention enters respectively at least five light flux from the Mitsuteru (1-1) gunner stage in two or more points of a tested area of this specimen plane from an oblique direction at a specimen plane, When a detection means detects at least five reflected light flux from this specimen plane and surface position information of this specimen plane is detected using an output signal from this detection means, This few **** from this optical irradiation means five light flux, When this specimen plane is observed from a direction vertical to this specimen plane, optical-path arrangement is carried out and this few **** enters so that five light flux may be observed independently mutually, and it is characterized by said thing [that said detection means has detected two or more catoptric light from each point via an individual optical system]. In particular, five light flux from said (1-1-1) Mitsuteru gunner stage is made to enter into said specimen plane by the mutual almost same incidence angle phi (angle to said perpendicular direction), and this incidence angle phi should fill phi>=70 degrees.

(1-1-2) said Mitsuteru gunner stage passes a common optical system -- said at least five light flux -- said -- leading more than one to a point, respectively -- this -- after reflected light flux from two or more points passes a common optical system, be detected by said detection means via said individual optical system.

(1-1-3) Said at least five light flux should enter from a direction which rotated only the predetermined angle theta which is not 0 degree within a specimen plane to a predetermined direction in which said two or more tested areas were arranged. It is characterized by **.

[0013]When a manufacturing method of a semiconductor device of this invention manufactures a

semiconductor device via a process in which projection exposure of the circuit pattern of reticle (2-1) is carried out to two or more shot regions arranged by a projection optical system in a wafer surface top determined direction, At least five light flux from the Mitsuteru gunner stage to two or more points of a shot region on a wafer surface from an oblique direction, At four points that a center and each of this shot region are located at a vertex of a predetermined quadrangle. When this shot region is observed from a direction vertical to this shot region, you carry out optical-path arrangement and this few **** makes it enter so that five light flux may be observed independently mutually, A detection means detects at least five reflected light flux from this shot region via an individual optical system, After detecting surface position information of this shot region using an output signal from this detection means and positioning this shot region in the image surface of this projection optical system based on this surface position information, it is characterized by carrying out projection exposure of the circuit pattern of this reticle to this shot region according to this projection optical system. In particular, five light flux from said (2-1-1) Mitsuteru gunner stage is made to enter into said specimen plane by the mutual almost same incidence angle phi (angle to said perpendicular direction), and this incidence angle phi should fill phi>=70 degrees.
(2-1-2) said Mitsuteru gunner stage passes a common optical system -- said at least five light flux -- said -- leading more than one to a point, respectively -- this -- after reflected light flux from two or more points passes a common optical system, be detected by said detection means via said individual optical system.
(2-1-3) Said at least five light flux should enter from a direction which rotated only the predetermined angle theta which is not 0 degree within a specimen plane to said predetermined direction. It is characterized by **.
[0014]
[Example]Drawing 1 is an important section schematic diagram of Example 1 of this invention, and drawing 2 is some expansion explanatory views of drawing 1.
[0015]In drawing 1, the projection optical system (projection lens system) of a reduced type [1] and Ax are the optic axes of the projection optical system 1. 1a is reticle, and the circuit pattern is formed on the field and it is laying on the reticle stage 1b. 1c is an illumination system and is carrying out uniform illumination of the reticle 1a side top. The projection optical system 1 is carrying out reduction projection of the circuit pattern on a reticle 1a side on the 2nd page of the wafer. The wafer 2 is adsorbed and fixed on the 3rd page of a wafer stage. The wafer stage 3 is movable to the 2-way (x, y direction) within the field which intersects perpendicularly (inside of a x-y flat surface), and has come to be able to carry out inclination adjustment of the optic-axis Ax direction (the direction of z) and the optic axis Ax of the projection optical system 1 to it to the flat surface (x-y flat surface) which intersects perpendicularly with the optic axis Ax. It enables it to adjust arbitrarily the surface position of the wafer 2 which this laid on the 3rd page of the wafer stage. 4 is a stage control apparatus and is carrying out drive controlling of the wafer stage 3 based on the signal from the focus control device 18 mentioned later.
[0016]As for the Mitsuteru gunner stage and SB, a projection means and SC of SA are photoelectric conversion means, and these constitute some surface position sensing devices which detect the surface position information of the 2nd page of a wafer. Detection means SBC consists of projection means SB and a photoelectric conversion means SC.
[0017]In this example, when projecting the circuit pattern on a reticle 1a side on the 2nd page of a wafer by the projection optical system 1 using a surface position sensing device, drive controlling of the wafer stage 3 is carried out so that the exposure region on the 2nd page of a wafer may be located in the allowable depth of focus of the projection optical system 1. And the wafer stage 3 is moved one by one on a X-Y flat surface, and this forms the pattern space (shot) 39 (mm [20] x about 20 mm) of rectangular shape one by one on the 2nd page of a wafer.
[0018]Next, each element of the surface position sensing device of this example is explained. Mitsuteru gunner stage SA which enters two or more light flux on the 2nd page of a wafer first is

explained.
[0019]5 is a light source and comprises the lighting unit constituted so that it might irradiate with a white lamp or a different light of two or more wavelength. 6 is a collimator lens and the intensity distribution of a section has ejected the light flux from the light source 5 as a parallel pencil of abbreviated homogeneity. 7 is a prism-shaped slit member and has two or more openings (five pinholes) 71-75. 8 is a lens system and is carrying out the light guide of the five independent light flux 71a-75a which comprised both telecentric system and passed through two or more pinholes 71-75 of the slit member 7 via the mirror 9 at the five point of measurement 19-23 on the 2nd page of a wafer. The size of a projection image omits, and is and he is trying to serve as a pinhole image at this time. This lens system 8 has the aperture diaphragm 40 for arranging N.A of each light flux 71a-75a with an inside. At this example, Mitsuteru gunner stage SA consists of each above elements 5, 6, 7, 8, and 9.
[0020]In this example, the incidence angle phi to the 2nd page of wafer top of each light flux from Mitsuteru gunner stage SA (the altitude stood to the wafer surface and the angle to accomplish) is not less than phi= 70 degrees. On the 2nd page of a wafer, as shown in drawing 2, two or more pattern spaces (exposure region shot) 39 have arranged. The five light flux 71a-75a which passed the lens system 8 has entered into each point of measurement 19-23 in which the pattern space 39 carried out mutually-independent.
[0021]And it is made to enter on the 2nd page of a wafer from the direction of which theta** rotation was done in the XY plane from X (the direction of shot arrangement) so that it may be observed independently mutually, as it is shown in drawing 2, when the five light flux 71a-75a which enters on the 2nd page of a wafer observes from the perpendicular direction (the optic-axis Ax direction) of the wafer 2. The five pinholes 71-75 of the slit member 7 are formed on the wafer 2 and the same conjugate flat surface so that the conditions of the 2nd page of a wafer and a shine proof may be satisfied. The size of the pinholes 71-75 of the pinhole member 7, shape, the distance from the lens system 8, etc. are set up form the pinhole image of the size same in abbreviation mutually on the 2nd page of a wafer.
[0022]In this example, two or more light flux (pinhole) is entered on the 2nd page of a wafer by Mitsuteru gunner stage SA which comprises each above elements 5, 6, 7, 8, and 9. In this example, there may be the point of measurement on the 2nd page of a wafer how many not only in five points.
[0023]Next, projection means SB which carries out the light guide of two or more reflected light flux from the 2nd page of a wafer to the detecting face 17 of photoelectric conversion means SC as a position detecting element which comprises CCD and to which it is made to carry out image formation is explained.
[0024]11 is a light-receiving lens, comprises both telecentric system and is reflecting five reflected light flux from the 2nd page of a wafer via the mirror 10. And the light-receiving lens 11 forms the pinhole image in each positions 24-28 to each point of measurement 19-23. Entering light of the light flux from the pinhole image of each positions 24-28 is carried out to the five amendment optical systems 12-16 established independently.
[0025]Since the light-receiving lenses 11 are both telecentric system, the optic axis has become parallel mutually, and the amendment optical systems 12-16 carry out re-image formation of the pinhole image formed in each positions 24-28 so that it may become the spot light of the same size mutually on the detecting face 17 of photoelectric conversion means SC. Photoelectric conversion means SC comprises single two-dimensional CCD. At this example, projection means SB consists of each above elements 10, 11, 12-16.
[0026]in addition -- the amendment optical systems 12-16 having each predetermined the plane-parallel plate and lens system of thickness, and receiving the optic axis of the light-receiving lens 11 -- a coaxis -- or eccentricity is carried out. At this time, the plane-parallel plate is used in order to amend the light path length of each lens system. the image formation magnification [lens system]

(projecting magnification) on the detecting face 17 of each point of measurement 19-23 -- abbreviation -- it has provided in order to amend so that it may become equal.
[0027]That is, when several point of measurement 19-23 when distance differs to the light-receiving lens 11 by the oblique incidence image formation optical system which carries out oblique incidence on a wafer surface carries out image formation of two or more light flux on the detecting face 17 of photoelectric conversion means SC like this example, the image formation magnification differs mutually.
[0028]then, the projecting magnification [in this example establish the amendment optical systems 12-16 to each point of measurement, and] on the detecting face 17 of each of these point of measurement 19-23 -- abbreviation -- he is trying to become equal (in addition, Japanese Patent Application No. No. 44236 [two to] of these people's point explains this amendment optical system in detail), and this time -- the surface position (a height direction.) of each point of measurement 19-23 of the 2nd page of a wafer He is trying for the position of the pinhole image (spot light) which enters on the detecting face 17 by the optic-axis Ax direction to change. Photoelectric conversion means SC has detected the position change of the pinhole image at this time. It enables it to detect the surface position information of each point of measurement 19-23 on the 2nd page of a wafer in the same accuracy by this at this example.
[0029]Via projection means SB, as each point of measurement 19-23 on the 2nd page of a wafer and the detecting face 17 of photoelectric conversion means SC serve as conjugate mutually, they are (amending by falling to each point of measurement 19-23). The position of the pinhole image on the detecting face 17 does not change with the local inclination to each point of measurement 19-23 by this, He answers change of the local height position of each point of measurement of the optic-axis Ax direction of the surface of the wafer 2, i.e., the height of the point of measurement 19-23, and is trying for the position of the pinhole image on the detecting face 17 to change. Photoelectric conversion means SC has detected the incidence position information on the pinhole image which entered on the 17th page of the detecting face. The incidence position information on the pinhole image in each point of measurement 19-23 obtained by photoelectric conversion means SC is inputted into the focus control means 18.
[0030]The focus control means 18 acquires the height information (surface position information) of each point of measurement 19-23 from photoelectric conversion means SC, and is asking for the inclination to the position and X-Y flat surface about the surface position information (direction of z), i.e., optic-axis Ax direction, of the wafer 2, etc. from this.
[0031]And the signal about the drive quantity of the wafer stage 3 is inputted into the stage control apparatus 4 so that the surface of the wafer 2 may be abbreviated-in agreement with the surface of projection of the reticle 1a by the projection optical system 1. The stage control apparatus 4 carries out drive controlling of the wafer stage 3 according to the input signal from the focus control means 18, and is adjusting the position and posture of the wafer 2.
[0032]Next, the feature on arrangement of each element at the time of entering light flux in two or more point of measurement (19-23) on the 2nd page of a wafer in this example, and forming a pinhole image is explained.
[0033]Two or more point of measurement 19-23 on the 2nd page of the wafer in this example is set as the abbreviated center of four corners of the pattern space (shot) 39 of the rectangular shape of the wafer 2, and four corners of those, as shown in drawing 2. And each point of measurement 71-75 is irradiated with each pinholes 71-75 and the light flux which came out from the direction of which angle theta (the figure theta= 22.5 degrees) rotation was done from the direction of X of the pattern space 39 of rectangular shape by Mitsuteru gunner stage SA.
[0034]When the light flux from each pinholes 71-75 of Mitsuteru gunner stage SA observes from the perpendicular direction of the wafer 2 at this time, it is made to enter on the 2nd page of a wafer so that it may be observed independently mutually.
[0035]drawing 3 -- A-A' of drawing 1 -- it is an explanatory view showing the spacial configuration

of the amendment optical systems 12-16 in a section.
[0036]In this example, oblique incidence of the incidence angle phi of drawing 1 is carried out so that it may become not less than phi= 70 degrees. therefore, if the relative distance of the center to center of the amendment optical systems 12-16 tends to form the point of measurement at equal intervals on the 2nd page of a wafer when the light flux from Mitsuteru gunner stage SA is carrying out oblique incidence on the 2nd page of the wafer, the direction of aa' of drawing 3 will become narrow less than with cosphi twice, i.e., 0.34 time, compared with the direction of bb'.
[0037]Since the diameter of the amendment optical systems 12-16 is generally needed about at least 4-5 mm on manufacture, it becomes difficult to arrange so that it may not interfere in two or more amendment optical systems mechanical mutually.
[0038]So, in this example, to the light flux from Mitsuteru gunner stage SA, theta**22.5 degrees of pattern spaces 39 of rectangular shape are rotated, as shown in drawing 2. It enables it to arrange independently respectively spatially, without the center of the amendment optical systems 12-16 having coordinates with same direction of aa' and direction of bb' mutually by this. The angle theta at this time should just be an angle observed independently mutually, when the five light flux 71a-75a sees from the perpendicular direction of the 2nd page of a wafer not only like 22.5 degrees but like the above-mentioned.
[0039]Drawing 4 shows the incidence state of five light flux which enters on the 2nd page of a wafer when the angle theta shown in drawing 2 is theta= 0 degree. The light flux which entered into the point of measurement 19 and 22 and the point of measurement 20 and 23 as shown in the figure laps mutually, and is observed.
[0040]Drawing 5 is an explanatory view of the spacial configuration of the amendment optical systems 12-16 as shown in drawing 4, when entering light flux. As shown in the figure, the amendment optical systems 12 and 15 corresponding to the point of measurement 19 and 22 interfere mechanical, the amendment optical systems 13 and 16 corresponding to the point of measurement 20 and 23 interfere mechanical, and it becomes impossible to arrange the amendment optical system of these spatially for this reason.
[0041]Drawing 6 shows the incidence state of five light flux which enters on the 2nd page of a wafer when it is similarly considered as the angle of theta= 45 degrees. The light flux which entered into the point of measurement 19, 21, and 23 as shown in the figure laps mutually, and is observed.
[0042]Drawing 7 is an explanatory view of the spacial configuration of the amendment optical systems 12-16 as shown in drawing 6, when entering light flux. Since it interferes in the amendment optical systems 12, 14, and 16 corresponding to the point of measurement 19, 21, and 23 mechanical mutually, it becomes impossible to arrange these amendment optical systems spatially.
[0043]On the other hand, as it is considered as theta**22.5 degrees and becomes the spacial configuration of the amendment optical systems 12-16 left as the distance of a center to center showed drawing 3 respectively, the amendment optical systems 12-16 enable it to arrange easily spatially like the above-mentioned in this example.
[0044]By constituting each element as mentioned above in this example, the abbreviation for a size, etc. are carried out like the above-mentioned by Mitsuteru gunner stage SA at the five point of measurement 19-23 on the 2nd page of a wafer, and it is, and is irradiating with the pinhole image (formation). And the abbreviation for a size, etc. are carried out to the detecting face 17 of photoelectric conversion means SC by projection means SB using five catoptric light from each point of measurement 19-23, it is, and re-image formation of the pinhole image is carried out. Photoelectric conversion means SC has detected the incidence position information on the pinhole image which enters on the detecting face 17 which changes with the height (the optic-axis Ax direction) of the 2nd page of a wafer at this time. And photoelectric conversion means SC has inputted the incidence position information on the pinhole image on the detecting face 17 at this time into the focus control device 18. The focus control device 18 found the height of the wafer 2 every point of measurement 19-23 based on the signal from photoelectric conversion means SC,

and has inputted into the stage control apparatus 4 the height information acquired at this time.
[0045]The stage control apparatus 4 makes the wafer stage 3 drive based on the signal from the focus control device 18, and is locating the wafer 2 in the best image formation face of the projection optical system 1 from this. This performs projection exposure of the circuit pattern of the reticle 1a on the 2nd page of a wafer, and the high-density semiconductor device is manufactured.
[0046]Drawing 8 is an important section schematic diagram of Example 2 of this invention. The same code number is given to the same element as the element shown by drawing 1 in drawing 8.
[0047]Compared with Example 1 of drawing 1, into the optical path between the light-receiving lens 11 and the amendment optical systems 12-16, make it correspond to the amendment optical systems 12-16, and the five mirrors 24-28 are formed in this example, It differs in that the light guide of the light flux from the light-receiving lens 11 is carried out to the amendment optical systems 12-16 via these mirrors 24-28, and other composition is substantially the same.
[0048]Re-image formation of the pinhole image formed with the light-receiving lens 11 on each point of measurement 19-23 on the 2nd page of a wafer is carried out to the positions 24-28 near the reflective spot of the mirrors 34-38 arranged on the optic axis of the amendment optical systems 12-16. It is enabled for about 24 to 28 position of re-image formation not to affect other light flux, but to arrange the individual mirrors 34-38 to each light flux, by this, since each light flux is condensing.
[0049]Thus, as the mirrors 34-38 are individually arranged to each light flux and this shows drawing 9, when the five amendment optical systems 12-16 are arranged spatially, Compared with the case where the relative distance of the direction of aa' does not arrange the mirror shown in drawing 3, it can take more widely, and, thereby, spatial arrangement of the amendment optical system is made easy.
[0050]Drawing 10 is an important section schematic diagram of Example 3 of this invention. The same code number is given to the same element as the element shown by drawing 1 in drawing 10.
[0051]The point of using the five sensing elements (elements, such as one-dimensional CCD and PSD) 41-45 made corresponding to each point of measurement 19-23 on the 2nd page of a wafer instead of single two-dimensional CCD constituting photoelectric conversion means SC of Example 1 of drawing 1 from this example, It differs in that the incidence position information on the pinhole image which arranges a mirror, forms a pinhole image in each sensing element, and enters using each sensing elements 41-45 at this time into an optical path is detected, and other composition is substantially the same.
[0052]It is made to reflect by the mirrors 48 and 49 arranged at 26 or about 27 image formation point when image formation of the pinhole image is carried out with the light-receiving lens 11, and the light flux from the point of measurement 20 and 22 on the 2nd page of a wafer is entered in the amendment optical systems 13 and 15. And re-image formation of the pinhole image is carried out on the 42 or 44th page of the sensing element according to the amendment optical systems 13 and 15. Since the mirrors 48 and 49 at this time are arranged near the position which light flux is condensing, light is reflected without affecting other light flux. It condensed with the light-receiving lens 11, and image formation of the pinhole image was carried out to the positions 24 and 28, and it condensed according to the post correction optical systems 12 and 16, and reflected by the mirrors 46 and 47, and the light flux from the point of measurement 19 and 23 on the 2nd page of a wafer has entered on the 41 or 45th page of a sensing element. And re-image formation of the pinhole image is carried out on the 41 or 45th page of the sensing element.
[0053]After it is condensed with the light-receiving lens 11 and the light flux from the point of measurement 21 on the 2nd page of a wafer carries out image formation of the pinhole image to the position 26, it is carrying out re-image formation of the pinhole image on the 43rd page of the sensing element according to the amendment optical system 14.
[0054]When entering two or more light flux from Mitsuteru gunner stage SA on the 2nd page of a wafer, he makes it enter as about theta= 22.5 degrees of angles of direction to a x direction, as

shown in drawing 2 to the wafer 2, and is trying for the interval on the spacial configuration of each light flux to become large in this example. It enables it to arrange the individual sensing elements 41-45 easily spatially by this corresponding to each point of measurement 19-23. It makes it possible to carry out parallel processing of the output signal from the sensing elements 41-45 based on each point of measurement 19-23, and improvement in the speed of signal processing is attained.

[0055]In this example, since a digital disposal circuit can simplify compared with the case where one-dimensional CCD is used and signal processing can be accelerated if PSD is used as a sensing element, it is desirable.

[0056]Drawing 11 is an important section schematic diagram showing only the Mitsuteru gunner stage SA portion of Example 4 of this invention. In the figure, it is the same as the composition of drawing 1 about the composition after the slit member 7.

[0057]In this example, the light flux from the light source 50 is entered in the entrance plane 56a of the fiber 56 using the condenser 51, and the one pinhole 75 of the slit member 7 is illuminated according to the light flux ejected from the projection surface 56b of the fiber 56. It is carrying out using the light source of the same composition, the condenser, and the fiber also about the lighting of other pinholes 71-74 of the slit member 7. The light source 50 comprises lighting YURITTO which irradiates with a white lamp or the different light flux of two or more wavelength.

[0058]Drawing 12 is a C-C'sectional view showing arrangement of the pinholes 71-75 of the slit member 7 of drawing 11. In this example, as shown in drawing 2, about theta= 22.5 degrees and the spatial interval of each pinholes 71-75 are made large for the angle theta to a x direction when entering light flux in passing on a wafer surface. Even if lighting by the individual fibers 52-56 is enabled to each pinholes 71-75 by this, for example, the reflectance of each point of measurement 19-23 on the 2nd page of a wafer differs, Light volume is adjusted individually, light volume of the catoptric light from each point of measurement 19-23 is made equal, and detection of highly precise surface position information is enabled.

[0059]

[Effect of the Invention]Carry out optical-path arrangement and two or more points are entered from an oblique direction so that at least five light flux may be observed independently mutually, when a tested area is observed [this invention] from a direction vertical to this tested area as mentioned above, It had composition which detects at least five reflected light flux from this tested area by a detection means via an individual optical system.

Therefore, when the extreme proximity state of the optical paths of reflected light flux as shown in drawing 5 or drawing 7 can be avoided and it therefore arranges an individual (for example, amendment) optical system to the detection system side even if the oblique-incidence angle phi is sudden composition for example, it can do [making these spacial configurations easy or].

Therefore, for example, even if the surface position sensing device set up appropriately detects the height information (surface position information) of two or more points in the exposure region on a wafer surface and the wafer surface is carrying out uneven shape by this, Even if it leans, the whole exposure region on this wafer surface can be easily located in the allowable depth of focus of a projection optical system, and the manufacturing method of a semiconductor device using the surface position sensing device and it which can manufacture a high-density semiconductor device by this can be attained.

[Translation done.]

TECHNICAL FIELD

[Industrial Application]When this invention carries out reduction projection of the electronic circuit pattern currently formed on the reticle side on a wafer surface according to a projection optical system in the projection aligner for semiconductor device manufacture, The surface position information (height information) of two or more points on this wafer surface can be detected, the exposure region of this wafer can be easily located in the best image formation face of a projection optical system, and it is related with the surface position sensing device with which a good projection image is acquired, and the manufacturing method of a semiconductor device using it.

[Translation done.]

PRIOR ART

[Description of the Prior Art]In recent years, the minuteness making about a half micron and high integration are demanded of the projection aligner for semiconductor device manufacture from the minuteness making of the electronic circuit pattern, for example, a submicron. censure -- in connection with this, the thing with higher resolution than before is demanded from the projection optical system. For this reason, in the projection optical system, short wavelength formation is attained to the formation of high N.A, and an exposure wavelength.
[0003]Generally, about high-resolving-power-ization of a projection optical system, if a figure wax and N.A are made high, the allowable depth of focus of pattern projection will become shallow. For this reason, with many projection aligners, the surface position sensing device which detects the focal plane position of a projection optical system is used.It is requested that it not only detects and adjusts the height position (surface position) information on the exposure region on the wafer surface which only performs pattern transfer to this surface position sensing device, but it detects simultaneously inclination to the exposure region on the wafer surface which performs pattern transfer, etc., and can adjust them.
[0004]As a surface position sensing device of a focal plane, two or more air sensors are formed in the periphery of the exposure region on a wafer surface from before, and the method of computing and adjusting inclination, a height position, etc. of an exposure region from the height information of the exposure region periphery obtained from this air sensor is known.
[0005]In addition, in JP,2-10361,B, the height information of the central part of an exposure region is detected and adjusted with the height position detecting optical system of oblique incidence, and the method of detecting the inclination in an exposure region and adjusting with the detected inclination optical system (collimator) of oblique incidence established apart from this is proposed.

[Translation done.]

EFFECT OF THE INVENTION

[Effect of the Invention]Carry out optical-path arrangement and two or more points are entered from an oblique direction so that at least five light flux may be observed independently mutually, when a tested area is observed [this invention] from a direction vertical to this tested area as mentioned above, It had composition which detects at least five reflected light flux from this tested area by a detection means via an individual optical system.
Therefore, when the extreme proximity state of the optical paths of reflected light flux as shown in drawing 5 or drawing 7 can be avoided and it therefore arranges an individual (for example, amendment) optical system to the detection system side even if the oblique-incidence angle phi is sudden composition for example, it can do [making these spacial configurations easy or].
Therefore, for example, even if the surface position sensing device set up appropriately detects the height information (surface position information) of two or more points in the exposure region on a wafer surface and the wafer surface is carrying out uneven shape by this, Even if it leans, the whole exposure region on this wafer surface can be easily located in the allowable depth of focus of a projection optical system, and the manufacturing method of a semiconductor device using the surface position sensing device and it which can manufacture a high-density semiconductor device by this can be attained.

[Translation done.]

TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention]When unevenness and smooth inclination are in the exposure region on the wafer surface which generally performs pattern transfer, it is very difficult to locate this exposure region in the allowable depth of focus of a projection optical system.
[0007]For example, as shown in drawing 13, the exposure region 90 on a wafer surface assumes that it had become convex [smooth] (it is the same as that of the following even if it is a concave.). The position in the point of measurement 91a of two or more peripheries of the exposure region 90 can be made to agree in the best image formation face 92 of a projection optical system in the method of arranged and measuring an air sensor to two or more peripheries of the former exposure region at this time, as shown in drawing 14. However, there was a problem that the center section 91b of the exposure region 90 will separate from 93 in the allowable depth of focus.
[0008]The method of using the latter height position detecting optical system and detected inclination optical system by oblique incidence makes the position of the point of measurement 94 of the center section of the exposure region 90 agree in the best image formation face 92 of a projection optical system, as shown in drawing 15, and it can make average inclination 95 to the whole exposure region parallel to the best image formation face 92.
[0009]However, this method had the problem that the periphery of the exposure region 90 could not be located in 93 in the allowable depth of focus. The problem at this time can locate the exposure region 90 whole in 93 in the allowable depth of focus, if two or more point of measurement 96 is taken in the exposure region 90 at a center section and a periphery as shown, for example in drawing 16.
[0010]In the projection aligner for semiconductor device manufacture, this method However, the lower part of a projection optical system, Since members, such as a laser interferometer for wafer stage control and a microscope for wafer alignment, were arranged in space, i.e., the space of a wafer stage periphery, there was a problem that it was very difficult to form two or more surface position sensing devices in it.
[0011]Whether the surface position sensing device set up appropriately detects the height information (surface position information) of two or more points in the exposure region on a wafer surface, and the wafer surface is carrying out uneven shape by this or this invention leans, it can locate easily the whole exposure region on this wafer surface in the allowable depth of focus of a projection optical system. It aims at offer of the manufacturing method of a semiconductor device using the surface position sensing device and it which can manufacture a high-density semiconductor device by this.

[Translation done.]

* NOTICES *

MEANS

[Means for Solving the Problem]A surface position sensing device of this invention enters respectively at least five light flux from the Mitsuteru (1-1) gunner stage in two or more points of a tested area of this specimen plane from an oblique direction at a specimen plane, When a detection means detects at least five reflected light flux from this specimen plane and surface position information of this specimen plane is detected using an output signal from this detection means, This few **** from this optical irradiation means five light flux, When this specimen plane is observed from a direction vertical to this specimen plane, optical-path arrangement is carried out and this few **** enters so that five light flux may be observed independently mutually, and it is characterized by said thing [that said detection means has detected two or more catoptric light from each point via an individual optical system]. In particular, five light flux from said (1-1-1) Mitsuteru gunner stage is made to enter into said specimen plane by the mutual almost same incidence angle phi (angle to said perpendicular direction), and this incidence angle phi should fill phi>=70 degrees.
(1-1-2) said Mitsuteru gunner stage passes a common optical system -- said at least five light flux -- said -- leading more than one to a point, respectively -- this -- after reflected light flux from two or more points passes a common optical system, be detected by said detection means via said individual optical system.
(1-1-3) Said at least five light flux should enter from a direction which rotated only the predetermined angle theta which is not 0 degree within a specimen plane to a predetermined direction in which said two or more tested areas were arranged. It is characterized by **.
[0013]When a manufacturing method of a semiconductor device of this invention manufactures a semiconductor device via a process in which projection exposure of the circuit pattern of reticle (2-1) is carried out to two or more shot regions arranged by a projection optical system in a wafer surface top determined direction, At least five light flux from the Mitsuteru gunner stage to two or more points of a shot region on a wafer surface from an oblique direction, At four points that a center and each of this shot region are located at a vertex of a predetermined quadrangle. When this shot region is observed from a direction vertical to this shot region, you carry out optical-path arrangement and this few **** makes it enter so that five light flux may be observed independently mutually, A detection means detects at least five reflected light flux from this shot region via an individual optical system, After detecting surface position information of this shot region using an output signal from this detection means and positioning this shot region in the image surface of this projection optical system based on this surface position information, it is characterized by carrying out projection exposure of the circuit pattern of this reticle to this shot region according to this projection optical system. In particular, five light flux from said (2-1-1) Mitsuteru gunner stage is made to enter into said specimen plane by the mutual almost same incidence angle phi (angle to said perpendicular direction), and this incidence angle phi should fill phi>=70 degrees.
(2-1-2) said Mitsuteru gunner stage passes a common optical system -- said at least five light flux

-- said -- leading more than one to a point, respectively -- this -- after reflected light flux from two or more points passes a common optical system, be detected by said detection means via said individual optical system.
(2-1-3) Said at least five light flux should enter from a direction which rotated only the predetermined angle theta which is not 0 degree within a specimen plane to said predetermined direction. It is characterized by **.

[Translation done.]

EXAMPLE

[Example]Drawing 1 is an important section schematic diagram of Example 1 of this invention, and drawing 2 is some expansion explanatory views of drawing 1.
[0015]In drawing 1, the projection optical system (projection lens system) of a reduced type [1] and Ax are the optic axes of the projection optical system 1. 1a is reticle, and the circuit pattern is formed on the field and it is laying on the reticle stage 1b. 1c is an illumination system and is carrying out uniform illumination of the reticle 1a side top. The projection optical system 1 is carrying out reduction projection of the circuit pattern on a reticle 1a side on the 2nd page of the wafer. The wafer 2 is adsorbed and fixed on the 3rd page of a wafer stage. The wafer stage 3 is movable to the 2-way (x, y direction) within the field which intersects perpendicularly (inside of a x-y flat surface), and has come to be able to carry out inclination adjustment of the optic-axis Ax direction (the direction of z) and the optic axis Ax of the projection optical system 1 to it to the flat surface (x-y flat surface) which intersects perpendicularly with the optic axis Ax. It enables it to adjust arbitrarily the surface position of the wafer 2 which this laid on the 3rd page of the wafer stage. 4 is a stage control apparatus and is carrying out drive controlling of the wafer stage 3 based on the signal from the focus control device 18 mentioned later.
[0016]As for the Mitsuteru gunner stage and SB, a projection means and SC of SA are photoelectric conversion means, and these constitute some surface position sensing devices which detect the surface position information of the 2nd page of a wafer. Detection means SBC consists of projection means SB and a photoelectric conversion means SC.
[0017]In this example, when projecting the circuit pattern on a reticle 1a side on the 2nd page of a wafer by the projection optical system 1 using a surface position sensing device, drive controlling of the wafer stage 3 is carried out so that the exposure region on the 2nd page of a wafer may be located in the allowable depth of focus of the projection optical system 1. And the wafer stage 3 is moved one by one on a X-Y flat surface, and this forms the pattern space (shot) 39 (mm [20] x about 20 mm) of rectangular shape one by one on the 2nd page of a wafer.
[0018]Next, each element of the surface position sensing device of this example is explained. Mitsuteru gunner stage SA which enters two or more light flux on the 2nd page of a wafer first is explained.
[0019]5 is a light source and comprises the lighting unit constituted so that it might irradiate with a white lamp or a different light of two or more wavelength. 6 is a collimator lens and the intensity distribution of a section has ejected the light flux from the light source 5 as a parallel pencil of abbreviated homogeneity. 7 is a prism-shaped slit member and has two or more openings (five pinholes) 71-75. 8 is a lens system and is carrying out the light guide of the five independent light flux 71a-75a which comprised both telecentric system and passed through two or more pinholes 71-75 of the slit member 7 via the mirror 9 at the five point of measurement 19-23 on the 2nd page of a wafer. The size of a projection image omits, and is and he is trying to serve as a pinhole image at this time. This lens system 8 has the aperture diaphragm 40 for arranging N.A of each light flux

71a-75a with an inside. At this example, Mitsuteru gunner stage SA consists of each above elements 5, 6, 7, 8, and 9.
[0020]In this example, the incidence angle phi to the 2nd page of wafer top of each light flux from Mitsuteru gunner stage SA (the altitude stood to the wafer surface and the angle to accomplish) is not less than phi= 70 degrees. On the 2nd page of a wafer, as shown in drawing 2, two or more pattern spaces (exposure region shot) 39 have arranged. The five light flux 71a-75a which passed the lens system 8 has entered into each point of measurement 19-23 in which the pattern space 39 carried out mutually-independent.
[0021]And it is made to enter on the 2nd page of a wafer from the direction of which theta** rotation was done in the XY plane from X (the direction of shot arrangement) so that it may be observed independently mutually, as it is shown in drawing 2, when the five light flux 71a-75a which enters on the 2nd page of a wafer observes from the perpendicular direction (the optic-axis Ax direction) of the wafer 2. The five pinholes 71-75 of the slit member 7 are formed on the wafer 2 and the same conjugate flat surface so that the conditions of the 2nd page of a wafer and a shine proof may be satisfied. The size of the pinholes 71-75 of the pinhole member 7, shape, the distance from the lens system 8, etc. are set up form the pinhole image of the size same in abbreviation mutually on the 2nd page of a wafer.
[0022]In this example, two or more light flux (pinhole) is entered on the 2nd page of a wafer by Mitsuteru gunner stage SA which comprises each above elements 5, 6, 7, 8, and 9. In this example, there may be the point of measurement on the 2nd page of a wafer how many not only in five points.
[0023]Next, projection means SB which carries out the light guide of two or more reflected light flux from the 2nd page of a wafer to the detecting face 17 of photoelectric conversion means SC as a position detecting element which comprises CCD and to which it is made to carry out image formation is explained.
[0024]11 is a light-receiving lens, comprises both telecentric system and is reflecting five reflected light flux from the 2nd page of a wafer via the mirror 10. And the light-receiving lens 11 forms the pinhole image in each positions 24-28 to each point of measurement 19-23. Entering light of the light flux from the pinhole image of each positions 24-28 is carried out to the five amendment optical systems 12-16 established independently.
[0025]Since the light-receiving lenses 11 are both telecentric system, the optic axis has become parallel mutually, and the amendment optical systems 12-16 carry out re-image formation of the pinhole image formed in each positions 24-28 so that it may become the spot light of the same size mutually on the detecting face 17 of photoelectric conversion means SC. Photoelectric conversion means SC comprises single two-dimensional CCD. At this example, projection means SB consists of each above elements 10, 11, 12-16.
[0026]in addition -- the amendment optical systems 12-16 having each predetermined the plane-parallel plate and lens system of thickness, and receiving the optic axis of the light-receiving lens 11 -- a coaxis -- or eccentricity is carried out. At this time, the plane-parallel plate is used in order to amend the light path length of each lens system. the image formation magnification [lens system] (projecting magnification) on the detecting face 17 of each point of measurement 19-23 -- abbreviation -- it has provided in order to amend so that it may become equal.
[0027]That is, when several point of measurement 19-23 when distance differs to the light-receiving lens 11 by the oblique incidence image formation optical system which carries out oblique incidence on a wafer surface carries out image formation of two or more light flux on the detecting face 17 of photoelectric conversion means SC like this example, the image formation magnification differs mutually.
[0028]then, the projecting magnification [in this example establish the amendment optical systems 12-16 to each point of measurement, and] on the detecting face 17 of each of these point of measurement 19-23 -- abbreviation -- he is trying to become equal (in addition, Japanese Patent

Application No. No. 44236 [two to] of these people's point explains this amendment optical system in detail), and this time -- the surface position (a height direction.) of each point of measurement 19-23 of the 2nd page of a wafer He is trying for the position of the pinhole image (spot light) which enters on the detecting face 17 by the optic-axis Ax direction to change. Photoelectric conversion means SC has detected the position change of the pinhole image at this time. It enables it to detect the surface position information of each point of measurement 19-23 on the 2nd page of a wafer in the same accuracy by this at this example.

[0029]Via projection means SB, as each point of measurement 19-23 on the 2nd page of a wafer and the detecting face 17 of photoelectric conversion means SC serve as conjugate mutually, they are (amending by falling to each point of measurement 19-23). The position of the pinhole image on the detecting face 17 does not change with the local inclination to each point of measurement 19-23 by this, He answers change of the local height position of each point of measurement of the optic-axis Ax direction of the surface of the wafer 2, i.e., the height of the point of measurement 19-23, and is trying for the position of the pinhole image on the detecting face 17 to change. Photoelectric conversion means SC has detected the incidence position information on the pinhole image which entered on the 17th page of the detecting face. The incidence position information on the pinhole image in each point of measurement 19-23 obtained by photoelectric conversion means SC is inputted into the focus control means 18.

[0030]The focus control means 18 acquires the height information (surface position information) of each point of measurement 19-23 from photoelectric conversion means SC, and is asking for the inclination to the position and X-Y flat surface about the surface position information (direction of z), i.e., optic-axis Ax direction, of the wafer 2, etc. from this.

[0031]And the signal about the drive quantity of the wafer stage 3 is inputted into the stage control apparatus 4 so that the surface of the wafer 2 may be abbreviated-in agreement with the surface of projection of the reticle 1a by the projection optical system 1. The stage control apparatus 4 carries out drive controlling of the wafer stage 3 according to the input signal from the focus control means 18, and is adjusting the position and posture of the wafer 2.

[0032]Next, the feature on arrangement of each element at the time of entering light flux in two or more point of measurement (19-23) on the 2nd page of a wafer in this example, and forming a pinhole image is explained.

[0033]Two or more point of measurement 19-23 on the 2nd page of the wafer in this example is set as the abbreviated center of four corners of the pattern space (shot) 39 of the rectangular shape of the wafer 2, and four corners of those, as shown in drawing 2. And each point of measurement 71-75 is irradiated with each pinholes 71-75 and the light flux which came out from the direction of which angle theta (the figure theta= 22.5 degrees) rotation was done from the direction of X of the pattern space 39 of rectangular shape by Mitsuteru gunner stage SA.

[0034]When the light flux from each pinholes 71-75 of Mitsuteru gunner stage SA observes from the perpendicular direction of the wafer 2 at this time, it is made to enter on the 2nd page of a wafer so that it may be observed independently mutually.

[0035]drawing 3 -- A-A' of drawing 1 -- it is an explanatory view showing the spacial configuration of the amendment optical systems 12-16 in a section.

[0036]In this example, oblique incidence of the incidence angle phi of drawing 1 is carried out so that it may become not less than phi= 70 degrees. therefore, if the relative distance of the center to center of the amendment optical systems 12-16 tends to form the point of measurement at equal intervals on the 2nd page of a wafer when the light flux from Mitsuteru gunner stage SA is carrying out oblique incidence on the 2nd page of the wafer, the direction of aa' of drawing 3 will become narrow less than with cosphi twice, i.e., 0.34 time, compared with the direction of bb'.

[0037]Since the diameter of the amendment optical systems 12-16 is generally needed about at least 4-5 mm on manufacture, it becomes difficult to arrange so that it may not interfere in two or more amendment optical systems mechanical mutually.

[0038]So, in this example, to the light flux from Mitsuteru gunner stage SA, theta**22.5 degrees of pattern spaces 39 of rectangular shape are rotated, as shown in drawing 2. It enables it to arrange independently respectively spatially, without the center of the amendment optical systems 12-16 having coordinates with same direction of aa' and direction of bb' mutually by this. The angle theta at this time should just be an angle observed independently mutually, when the five light flux 71a-75a sees from the perpendicular direction of the 2nd page of a wafer not only like 22.5 degrees but like the above-mentioned.
[0039]Drawing 4 shows the incidence state of five light flux which enters on the 2nd page of a wafer when the angle theta shown in drawing 2 is theta= 0 degree. The light flux which entered into the point of measurement 19 and 22 and the point of measurement 20 and 23 as shown in the figure laps mutually, and is observed.
[0040]Drawing 5 is an explanatory view of the spacial configuration of the amendment optical systems 12-16 as shown in drawing 4, when entering light flux. As shown in the figure, the amendment optical systems 12 and 15 corresponding to the point of measurement 19 and 22 interfere mechanical, the amendment optical systems 13 and 16 corresponding to the point of measurement 20 and 23 interfere mechanical, and it becomes impossible to arrange the amendment optical system of these spatially for this reason.
[0041]Drawing 6 shows the incidence state of five light flux which enters on the 2nd page of a wafer when it is similarly considered as the angle of theta= 45 degrees. The light flux which entered into the point of measurement 19, 21, and 23 as shown in the figure laps mutually, and is observed.
[0042]Drawing 7 is an explanatory view of the spacial configuration of the amendment optical systems 12-16 as shown in drawing 6, when entering light flux. Since it interferes in the amendment optical systems 12, 14, and 16 corresponding to the point of measurement 19, 21, and 23 mechanical mutually, it becomes impossible to arrange these amendment optical systems spatially.
[0043]On the other hand, as it is considered as theta**22.5 degrees and becomes the spacial configuration of the amendment optical systems 12-16 left as the distance of a center to center showed drawing 3 respectively, the amendment optical systems 12-16 enable it to arrange easily spatially like the above-mentioned in this example.
[0044]By constituting each element as mentioned above in this example, the abbreviation for a size, etc. are carried out like the above-mentioned by Mitsuteru gunner stage SA at the five point of measurement 19-23 on the 2nd page of a wafer, and it is, and is irradiating with the pinhole image (formation). And the abbreviation for a size, etc. are carried out to the detecting face 17 of photoelectric conversion means SC by projection means SB using five catoptric light from each point of measurement 19-23, it is, and re-image formation of the pinhole image is carried out. Photoelectric conversion means SC has detected the incidence position information on the pinhole image which enters on the detecting face 17 which changes with the height (the optic-axis Ax direction) of the 2nd page of a wafer at this time. And photoelectric conversion means SC has inputted the incidence position information on the pinhole image on the detecting face 17 at this time into the focus control device 18. The focus control device 18 found the height of the wafer 2 every point of measurement 19-23 based on the signal from photoelectric conversion means SC, and has inputted into the stage control apparatus 4 the height information acquired at this time.
[0045]The stage control apparatus 4 makes the wafer stage 3 drive based on the signal from the focus control device 18, and is locating the wafer 2 in the best image formation face of the projection optical system 1 from this. This performs projection exposure of the circuit pattern of the reticle 1a on the 2nd page of a wafer, and the high-density semiconductor device is manufactured.
[0046]Drawing 8 is an important section schematic diagram of Example 2 of this invention. The same code number is given to the same element as the element shown by drawing 1 in drawing 8.
[0047]Compared with Example 1 of drawing 1, into the optical path between the light-receiving lens 11 and the amendment optical systems 12-16, make it correspond to the amendment optical systems 12-16, and the five mirrors 24-28 are formed in this example, It differs in that the light

guide of the light flux from the light-receiving lens 11 is carried out to the amendment optical systems 12-16 via these mirrors 24-28, and other composition is substantially the same.

[0048]Re-image formation of the pinhole image formed with the light-receiving lens 11 on each point of measurement 19-23 on the 2nd page of a wafer is carried out to the positions 24-28 near the reflective spot of the mirrors 34-38 arranged on the optic axis of the amendment optical systems 12-16. It is enabled for about 24 to 28 position of re-image formation not to affect other light flux, but to arrange the individual mirrors 34-38 to each light flux, by this, since each light flux is condensing.

[0049]Thus, as the mirrors 34-38 are individually arranged to each light flux and this shows drawing 9, when the five amendment optical systems 12-16 are arranged spatially, Compared with the case where the relative distance of the direction of aa' does not arrange the mirror shown in drawing 3, it can take more widely, and, thereby, spatial arrangement of the amendment optical system is made easy.

[0050]Drawing 10 is an important section schematic diagram of Example 3 of this invention. The same code number is given to the same element as the element shown by drawing 1 in drawing 10.

[0051]The point of using the five sensing elements (elements, such as one-dimensional CCD and PSD) 41-45 made corresponding to each point of measurement 19-23 on the 2nd page of a wafer instead of single two-dimensional CCD constituting photoelectric conversion means SC of Example 1 of drawing 1 from this example, It differs in that the incidence position information on the pinhole image which arranges a mirror, forms a pinhole image in each sensing element, and enters using each sensing elements 41-45 at this time into an optical path is detected, and other composition is substantially the same.

[0052]It is made to reflect by the mirrors 48 and 49 arranged at 26 or about 27 image formation point when image formation of the pinhole image is carried out with the light-receiving lens 11, and the light flux from the point of measurement 20 and 22 on the 2nd page of a wafer is entered in the amendment optical systems 13 and 15. And re-image formation of the pinhole image is carried out on the 42 or 44th page of the sensing element according to the amendment optical systems 13 and 15. Since the mirrors 48 and 49 at this time are arranged near the position which light flux is condensing, light is reflected without affecting other light flux. It condensed with the light-receiving lens 11, and image formation of the pinhole image was carried out to the positions 24 and 28, and it condensed according to the post correction optical systems 12 and 16, and reflected by the mirrors 46 and 47, and the light flux from the point of measurement 19 and 23 on the 2nd page of a wafer has entered on the 41 or 45th page of a sensing element. And re-image formation of the pinhole image is carried out on the 41 or 45th page of the sensing element.

[0053]After it is condensed with the light-receiving lens 11 and the light flux from the point of measurement 21 on the 2nd page of a wafer carries out image formation of the pinhole image to the position 26, it is carrying out re-image formation of the pinhole image on the 43rd page of the sensing element according to the amendment optical system 14.

[0054]When entering two or more light flux from Mitsuteru gunner stage SA on the 2nd page of a wafer, he makes it enter as about theta= 22.5 degrees of angles of direction to a x direction, as shown in drawing 2 to the wafer 2, and is trying for the interval on the spacial configuration of each light flux to become large in this example. It enables it to arrange the individual sensing elements 41-45 easily spatially by this corresponding to each point of measurement 19-23. It makes it possible to carry out parallel processing of the output signal from the sensing elements 41-45 based on each point of measurement 19-23, and improvement in the speed of signal processing is attained.

[0055]In this example, since a digital disposal circuit can simplify compared with the case where one-dimensional CCD is used and signal processing can be accelerated if PSD is used as a sensing element, it is desirable.

[0056]Drawing 11 is an important section schematic diagram showing only the Mitsuteru gunner

stage SA portion of Example 4 of this invention. In the figure, it is the same as the composition of drawing 1 about the composition after the slit member 7.
[0057]In this example, the light flux from the light source 50 is entered in the entrance plane 56a of the fiber 56 using the condenser 51, and the one pinhole 75 of the slit member 7 is illuminated according to the light flux ejected from the projection surface 56b of the fiber 56. It is carrying out using the light source of the same composition, the condenser, and the fiber also about the lighting of other pinholes 71-74 of the slit member 7. The light source 50 comprises lighting YURITTO which irradiates with a white lamp or the different light flux of two or more wavelength.
[0058]Drawing 12 is a C-C'sectional view showing arrangement of the pinholes 71-75 of the slit member 7 of drawing 11. In this example, as shown in drawing 2, about theta= 22.5 degrees and the spatial interval of each pinholes 71-75 are made large for the angle theta to a x direction when entering light flux in passing on a wafer surface. Even if lighting by the individual fibers 52-56 is enabled to each pinholes 71-75 by this, for example, the reflectance of each point of measurement 19-23 on the 2nd page of a wafer differs, Light volume is adjusted individually, light volume of the catoptric light from each point of measurement 19-23 is made equal, and detection of highly precise surface position information is enabled.

[Translation done.]

DESCRIPTION OF DRAWINGS

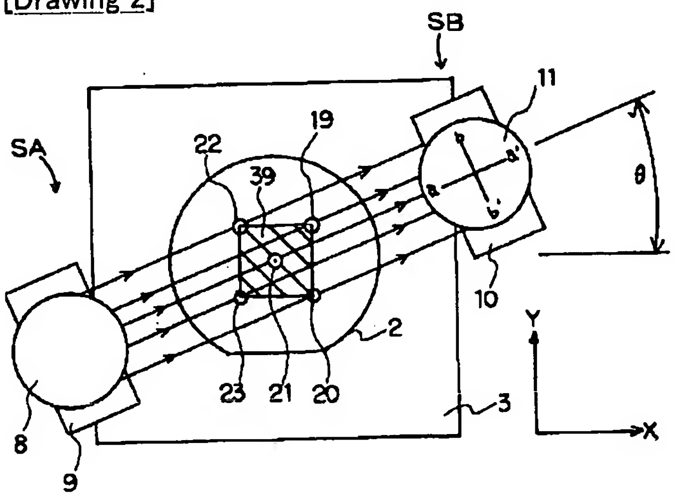
[Brief Description of the Drawings]
[Drawing 1]The important section schematic diagram of Example 1 of this invention
[Drawing 2]Some expansion explanatory views of drawing 1
[Drawing 3]The a-a'sectional view of drawing 1
[Drawing 4]An expansion explanatory view when the angle theta of drawing 2 is changed
[Drawing 5]The explanatory view showing arrangement of an amendment optical system in case drawing 4 shows
[Drawing 6]An expansion explanatory view when the angle theta of drawing 2 is changed
[Drawing 7]The explanatory view showing arrangement of an amendment optical system in case drawing 6 shows
[Drawing 8]The important section schematic diagram of Example 2 of this invention
[Drawing 9]The a-a'sectional view of drawing 8
[Drawing 10]The important section schematic diagram of Example 3 of this invention
[Drawing 11]Some schematic diagrams of Example 4 of this invention
[Drawing 12]The c-c'sectional view of drawing 11
[Drawing 13]Wafer type-like explanatory view
[Drawing 14]The explanatory view showing the physical relationship of a wafer surface and the allowable depth of focus of a projection lens
[Drawing 15]The explanatory view showing the physical relationship of a wafer surface and the allowable depth of focus of a projection lens
[Drawing 16]The explanatory view showing the physical relationship of a wafer surface and the allowable depth of focus of a projection lens
[Description of Notations]
SA The Mitsuteru gunner stage
SB Projection means
SC Photoelectric conversion means
1 Projection lens
1a Reticle
2 Wafer
3 Wafer stage
4 Stage control apparatus
5 Light source
6 Collimator lens
7 Slit member
8 Lens system
9 and 10 Mirror
11 Light-receiving lens

12-16 Amendment optical system
17 Detecting face
18 Focus control device
71-75 Pinhole

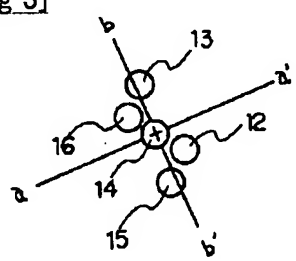
[Translation done.]

DRAWINGS

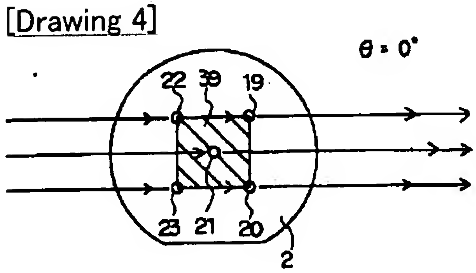
[Drawing 2]



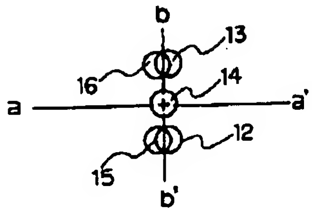
[Drawing 3]



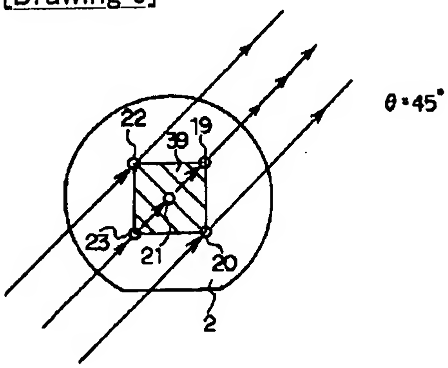
[Drawing 4]



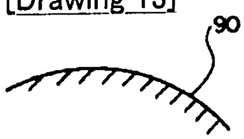
[Drawing 5]



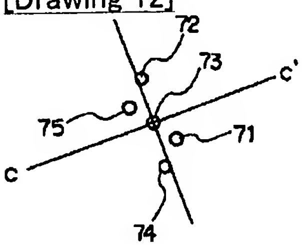
[Drawing 6]



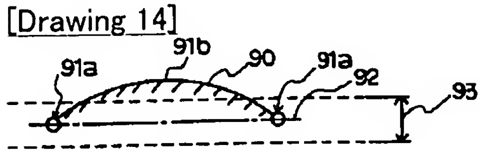
[Drawing 13]



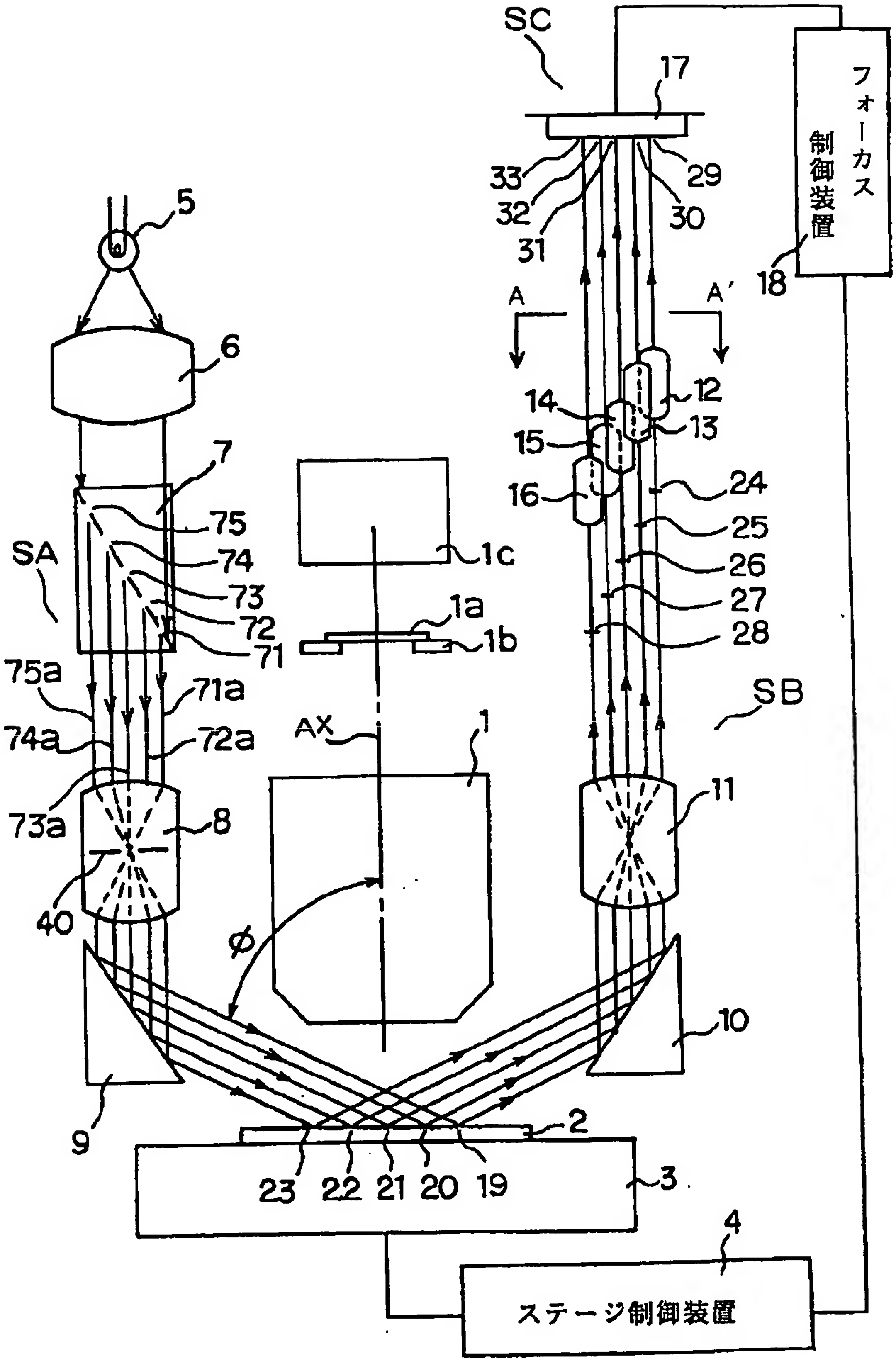
[Drawing 12]



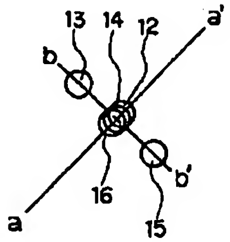
[Drawing 14]



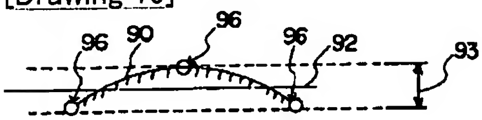
[Drawing 1]


SC
17
フォーカス制御装置
18
33
32
31
29
30
5
6
7
75
74
73
72
71
SA
75a
71a
74a
72a
73a
8
40
A
A'
14
15
16
12
13
24
25
26
27
28
1c
1a
1b
AX
1
SB
11
φ
9
10
2
23
22
21
20
19
3
4
ステージ制御装置

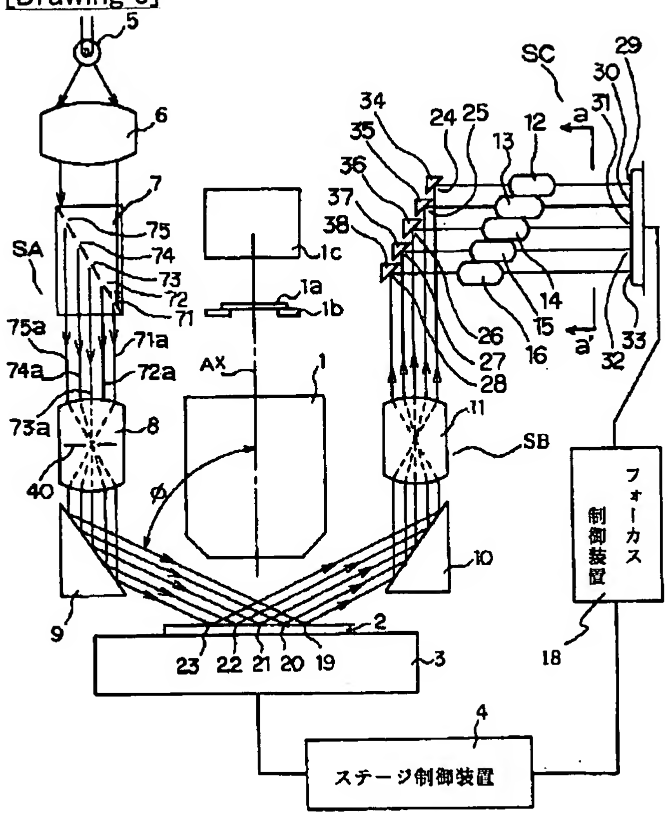
[Drawing 7]



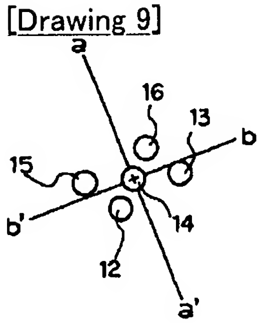
[Drawing 16]



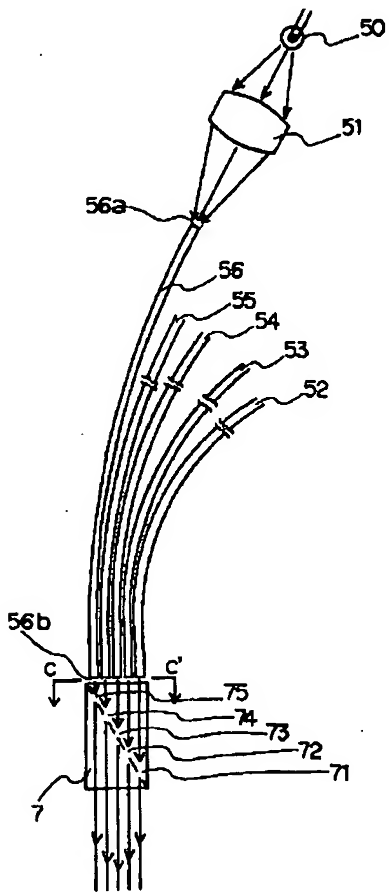
[Drawing 8]



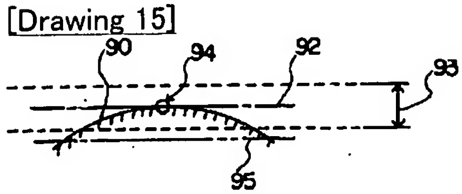
[Drawing 9]



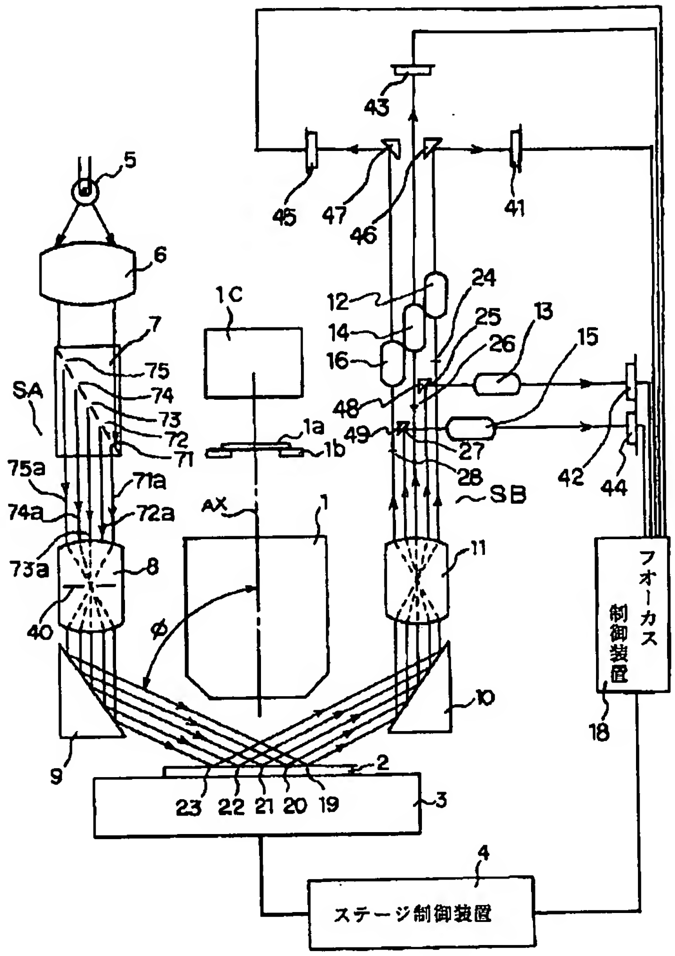
[Drawing 11]



[Drawing 15]



[Drawing 10]



[Translation done.]